



## FUTURE COMMUTE

> The amazing transport tech of tomorrow

## ALGAE WILL SAVE US!

> How green goo will start a new industrial revolution



AUSTRALIAN

# SCIENCE ILLUSTRATED



New **DEEP SEA** Discoveries!

NASA WANTS TO GO SAILING...

# Water Worlds

Where our solar system hides the wet stuff... and why we need it



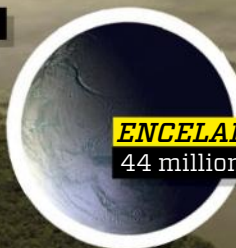
**EARTH**  
1,386 million km<sup>3</sup>



**CALLISTO**  
24,429 million km<sup>3</sup>



**TITAN**  
28,280 million km<sup>3</sup>



**ENCELADUS**  
44 million km<sup>3</sup>



**GANYMEDE**  
54,361 million km<sup>3</sup>



49

ISSUE #49 \$9.99 NZ \$10.99  
SCIENCEILLUSTRATED.COM.AU



## MAMMALS RULE!

Ever wondered why you aren't a lizard?

## FOREVER YOUNG

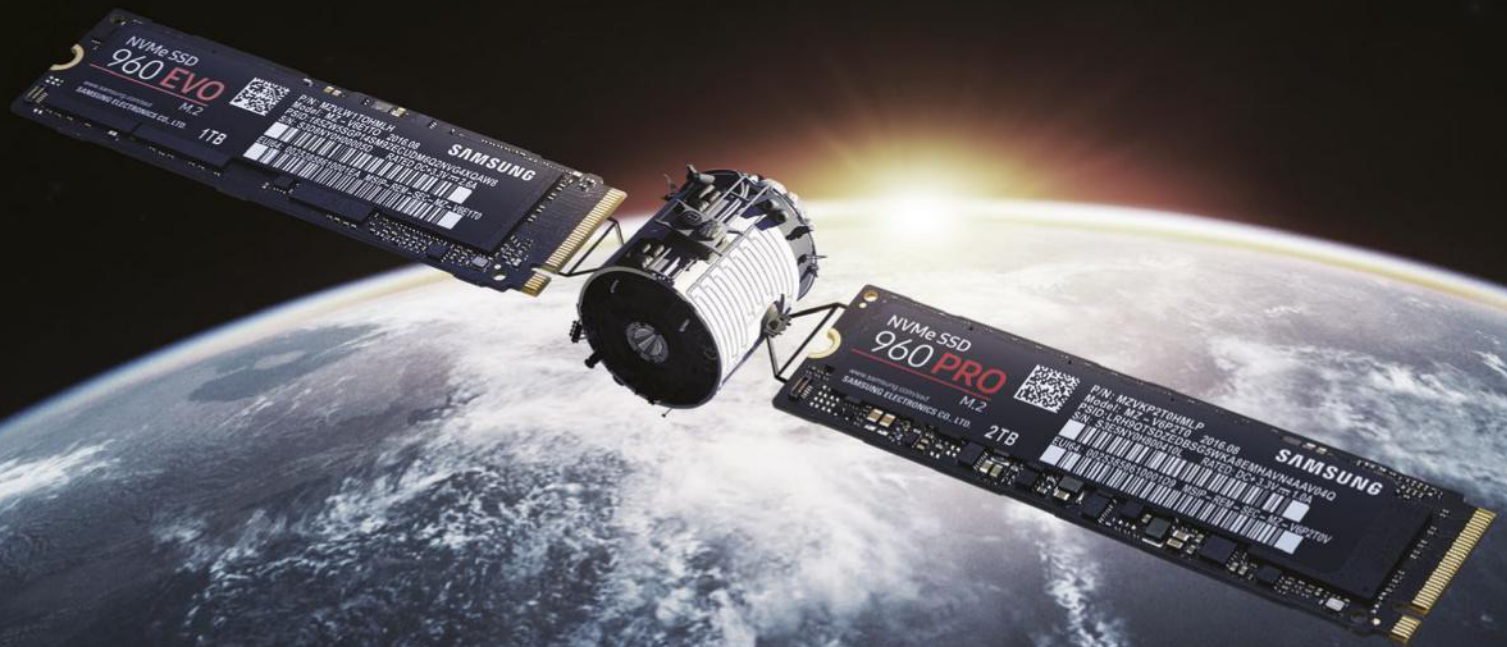
Science could stop us ageing... should it?





# SAMSUNG

L a u n c h i n g  
new possibilities

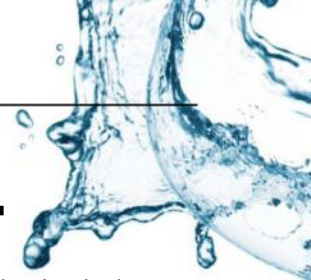


## NVMe SSD 960 PRO/ EVO

Experience the power of performance unleashed with NVMe PCIe Gen 3.0 X 4, packaged in an M.2 form factor offering exceptional storage capacity. The Samsung SSD 960 PRO and 960 EVO deliver performance beyond previous generations of Samsung SSDs, enabling you to do more. The SSD 960 PRO has sequential read and write speeds up to 3,500 MB/s and 2,100 MB/s, and up to 2TB capacity.\*

[www.samsung.com/au](http://www.samsung.com/au)

\* Maximum performance values for the 960 PRO. Results may vary based on the user environment.



# SCIENCE ILLUSTRATED

Issue #49 (23rd February 2017)

## EDITORIAL

Editor Anthony Fordham  
afordham@nextmedia.com.au

## DESIGN

Art Director Malcolm Campbell

## ADVERTISING

National Advertising Executive  
Lewis Preece lprece@nextmedia.com.au  
ph: 02 9901 6175

Production Manager Peter Ryman  
Circulation Director Carole Jones

## INTERNATIONAL EDITION

Editor-in-Chief Sebastian Reister  
International Editor Lotte Juul Nielsen

## BONNIER INTERNATIONAL MAGAZINES

International Licensing Director  
Julie Smartz  
Art Director Hanne Bo  
Picture Editors Allan Baggesø,  
Lisbeth Brännich, Peter Eberhardt

nextmedia

## NEXTMEDIA

Chief Executive Officer David Gardiner  
Commercial Director Bruce Duncan

Science Illustrated is published  
7 times a year by nextmedia Pty Ltd  
ACN: 128 805 970  
Building A, 207 Pacific Highway  
St Leonards, NSW 2065

Under license from Bonnier International Magazines. © 2014 Bonnier Corporation and nextmedia Pty Ltd. All Rights Reserved. Reproduction in whole or part without written permission is prohibited. Science Illustrated is a trademark of Bonnier Corporation and is used under limited license. The Australian edition contains material originally published in the US and UK editions reprinted with permission of Bonnier Corporation. Articles express the opinions of the authors and are not necessarily those of the Publisher, Editor or nextmedia Pty Ltd. ISSN 1836-5175.

## Privacy Notice

We value the integrity of your personal information. If you provide personal information through your participation in any competitions, surveys or offers featured in this issue of Science Illustrated, this will be used to provide the products or services that you have requested and to improve the content of our magazines. Your details may be provided to third parties who assist us in this purpose. In the event of organisations providing prizes or offers to our readers, we may pass your details on to them. From time to time, we may use the information you provide us to inform you of other products, services and events our company has to offer. We may also give your information to other organisations which may use it to inform you about their products, services and events, unless you tell us not to do so. You are welcome to access the information that we hold about you by getting in touch with our privacy officer, who can be contacted at nextmedia, Locked Bag 5555, St Leonards, NSW 1590

www.scienceillustrated.com.au

To subscribe, call 1300 361 146 or 9901 6111 or visit mymagazines.com.au

## THE SCIENCE ILLUSTRATED CREDO

We share with our readers a fascination with science, technology, nature, culture and archaeology, and believe that through education about our past, present and future, we can make the world a better place.

# Pour one out... for water



There's an old and very silly superstition that says it's bad luck to toast with water. If you can't get booze, you're supposed to use an empty glass rather than water. But what makes this "rule" so ridiculous is how important a role water plays in the life of every creature on our planet.

As a famous Hollywood mathematician once said: "life... uh... life finds a way." And life on Earth is indeed tenacious. From hot rocks deep in the crust, to the fake grout between imitation crazy-paving tiles, to a dirty toilet brush, life will find its niche. And life will make do with all kinds of weird resources to flourish.

No sun? Use chemosynthesis. No problem. A parasite already parasitised the host you wanted? Just parasitise the parasite!

But all life – be it elephant, cat, penguin, oak tree, lichen, bacteria, even viruses and prions that only get counted as life on a technicality – it all requires water.

All life on Earth is cell-based. And water allows cells to absorb nutrients and excrete wastes. It supports a cell's structure. It's the ultimate solvent, able to dissolve just about any other chemical given enough time.

And in our planet's orbit, water exists at the famous "triple point". Temperatures and pressures are such that it can exist in liquid phase (to support life), in gas phase (to warm the atmosphere) and as a solid (so glaciers and ice-caps grind away rocks and form landscapes and thus habitats for life).

Biologists can imagine – and often observe – all kinds of amazing adaptations that life uses to thrive in the most hostile environments. But always, there has to be a source of liquid water. Even a virus has water inside its tiny creepy lunar-lander alien-looking package of RNA.

Could life exist without water? Ammonia is

another electrically-charged molecule that can dissolve organic molecules and many elemental metals. Water is of course one oxygen and two hydrogen atoms. Ammonia is one nitrogen and three hydrogen atoms.

The problem with ammonia is that while water will happily accept an extra hydrogen or donate a hydrogen to form various useful compounds, ammonia is more likely to accept a hydrogen... look, it gets all chemistry-set and complicated, but the point is water does more stuff, forms more compounds. Water has higher surface tension and stronger bonds too.

Ammonia also won't freeze until -78 degrees, and it boils at -33 degrees. Of course, that's under Earth conditions, with our particular density of atmosphere.

Increase air pressure to 60 atmospheres, and ammonia boils at 98 degrees, or about the same as water. Chemical reactions take place more slowly in ammonia though, which means if we did meet intelligent ammonioids, they might speeeeak veeery sloooooowly...

Could conditions exist on a planet somewhere in the Milky Way conducive to ammonia-based life? Since there are likely to be billions of planets in our galaxy alone, the answer is probably... maybe?

Given what we know about physics and chemistry right now, there are fundamental reasons why water is the "key ingredient" for life. Exoplanets showing signs of water will always excite us more than hot rocks where it rains glass sideways. And the first confirmed liquid water ocean we spot? Expect that world to get a LOT of attention.

So here's to water. And I say toast with the stuff. It's an ingredient in almost all our food, after all. Respect it. Celebrate it. How could water possibly bring us bad luck? It's the only reason any of us are here at all.

**Anthony Fordham**

afordham@nextmedia.com.au

## THINGS WE LEARNED IN THIS ISSUE

- + The Earth is not **THE WETTEST PLANET** in the Solar System, when it comes to total water volume.
- + When mammals won a **MIGHTY VICTORY** over the dinosaurs, Earth never looked back.
- + Would you travel to work in an **AUTODRIVE CUBE** that travels at 200km/h or faster?
- + We've discovered amazing **NEW SPECIES** in the deepest parts of the ocean.
- + A factory using **PRIMITIVE ALGAE** could solve all our energy and pollution problems. Maybe.





# CONTENTS

**ISSUE #49** | **SCIENCE ILLUSTRATED AUSTRALIAN EDITION**  
PUBLISHED 23RD FEBRUARY 2017

## 24

### WATER WORLDS

Earth has its ocean, but that's little more than a puddle compared to the amount of water elsewhere in the Solar System...

COVER  
STORY

## 32

### THE MAMMALIAN VICTORY

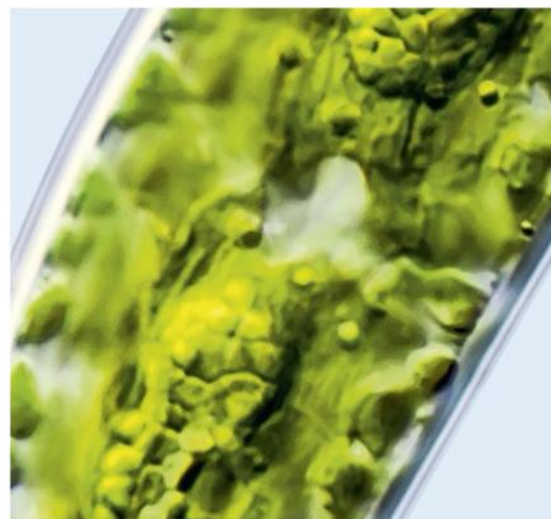
Lucky for us, millions of years ago reptiles and dinosaurs lost their grip on the biosphere. In the gap, mammals rose. Here's why we did so well.



## 54

### ALGAE FACTORY

The next industrial revolution won't be about steel or carbon or any other metal. It will be about tiny, single-cell plants...





# 40

## FUTURE OF TRANSPORT

Gridlock must die. Traffic must get smart. Autodrive has to be a thing. Beyond electric cars, here are our future transport options.



# 62

## FAT IS GOOD

There's a very good reason why your body stores excess energy as fat. We explore all the many good things body fat does for us.



# 46

## DEEP SEA CREATURES

Perhaps 50% of the species living in the deep ocean are unknown to science. Here's a collection of new discoveries. Ew.



# 58

## FOREVER YOUNG

Ageing is a disease. That's what some scientists think. And diseases can be cured. Could there be a child alive today who will live to 130?

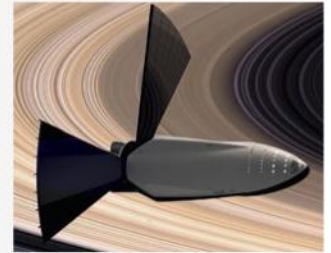


# REGULARS AND OTHER FEATURES

## 6

### MEGAPIXEL

There's fire down below...



## 10

### SCIENCE UPDATE

Elon Musk wants to you die on Mars!



## 18

### ASK US

Can we actually take a photograph of an exoplanet?



## 74

### EXTREME HEAT

Will Australia get too hot to bear?

## 78

### HOME CHEMISTRY LAB

Make super-strong soap bubbles!

## 80

### TRIVIA

Now with more potoo posulatons!

## 82

### BIODIVERSITY

An owl-like bird that's not an owl

# SUBSCRIBE NOW! → 60

Get Australian Science Illustrated delivered to your door and save \$\$\$!



## Devastation by flame will create new life...



80,000 people evacuated and 73 km<sup>3</sup> of forest converted into glowing "coal". Nevertheless, bushfires such as this one in southern California make up an important part of the ecosystem cycle. When dead trees and bushes burn, space is cleared and nutrients released, powering the growth of new plants. According to an experiment in Florida, 90+ % of the plant species of a forested area disappeared, when wildfires were fought down over four decades, so in several places, rangers use controlled fires to protect the ecosystem. Australia faces a similar dilemma in an even more volatile landscape.

■ Photo // Noah Berger







## Huge rocket factory allows mission to Mars



With a volume of 3.7 million m<sup>3</sup>, NASA's Vehicle Assembly Building rocket factory is one of the largest structures in the world. Right now, NASA is adding 10 sets of platforms which will allow the assembly of the 100+ m high Space Launch System rockets. The first unmanned rocket will be launched in 2018, and according to plan, the rockets will take humans to an asteroid in the next few decades and subsequently to Mars.

■ Photo // Kim Shiflett & MSFC







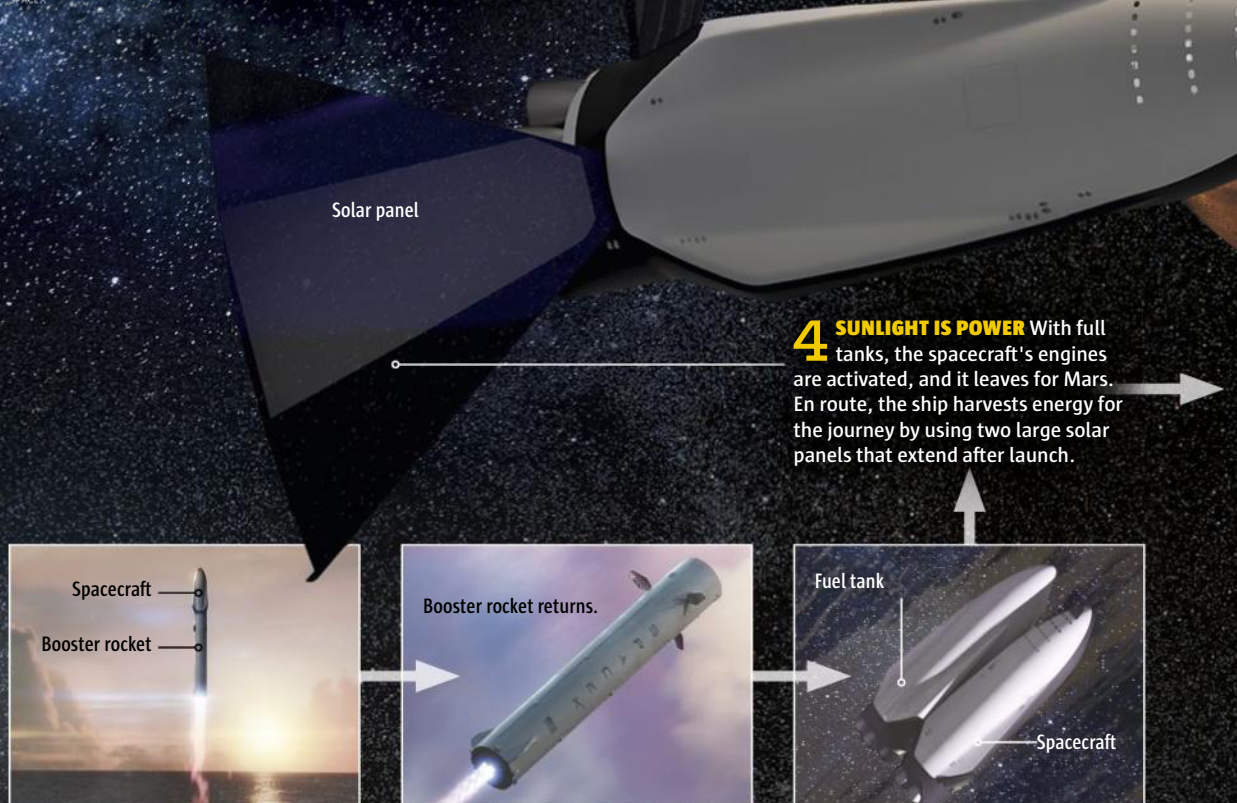


## WILD VISION

### Spacecraft can return to Earth

The ship's engines are powered by methane and oxygen, which both exist naturally on Mars, and so, the fuel tanks can be filled for the return.

SPACEX



## Huge rocket will take tourists to Mars

A huge booster rocket could launch at least 100 people at a time towards the Red Planet, paving the way for a colony on another world.

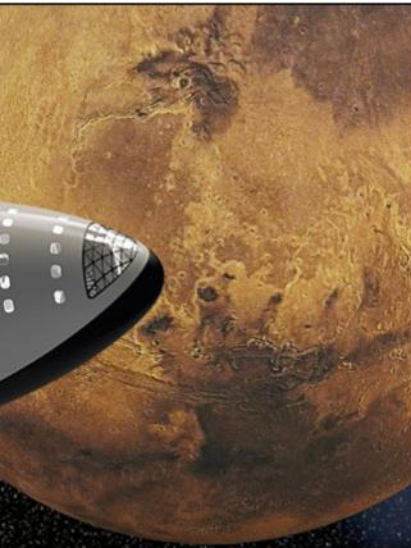
**AEROSPACE** The world's largest rocket is the backbone of SpaceX founder Elon Musk's wild vision of establishing a viable colony on Mars. He is dreaming of sending one million colonists to the Red Planet within the next 50-100 years.

After several years of development efforts, the man with the vision has introduced the ship that will take passengers to Mars. Including the spacecraft at the top, the reusable rocket rises a huge 122 m into the air – of which the spacecraft accounts for the top 49.5 m. First,

the spacecraft is placed in an orbit around Earth by means of the booster rocket, which will subsequently return to Earth. After being equipped with a fuel tank, the rocket returns to the spacecraft to fill the latter's tank. In this way, the launches from Earth include less weight to be lifted, keeping the price down.

The Raptor engines, which power the craft, use a combination of liquid methane and oxygen as fuel. Both are available on Mars, ensuring that the tanks can be refilled, so colonists or even tourists can return.





**5 LANDING** After 80 days of travelling through the universe, the spacecraft prepares for a rocket-controlled landing on Mars' surface.



**6 RETURN** The fuel tank can be refilled on Mars, allowing the colonists to return in the same spacecraft.

### FACTS ABOUT SPACEX

■ The man behind SpaceX, **Elon Musk**, is also the founder of the Tesla electric sports car brand and the driving force behind Hyperloop pneumatic tube transportation.

■ SpaceX was founded in California in 2002 with the aim of revolutionising aerospace technology and making it possible to colonise other planets.

■ In 2012, SpaceX became the first private company to send a ship to the ISS.



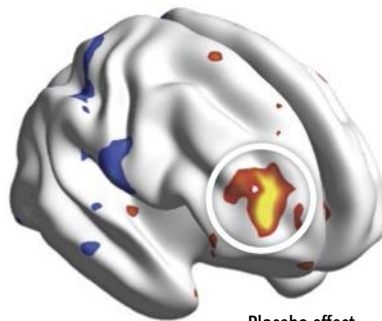
STEVE GRANITZ

## Scientists find placebo effect

**MEDICINE** The mysterious placebo effect is not so mysterious any more. Scientists from North-western University in Chicago have identified the region of the brain, where the effect is located, and which is the reason why calcium tablets can have a relieving or healing effect, even though they are not active drugs.

The point is located in the mid frontal gyrus – in the same place as the reward centre – according to research, to which 98 patients with chronic osteoarthritis in their knees contributed.

In the experiment, some of the patients were treated with ineffective pills and still experienced pain relief, and by using fMRI scans, scientists were able to accurately identify the brain region that reacted to the placebo.



Placebo effect

A special region of the brain is the reason why treatment with placebo drugs such as calcium tablets works.

PASCAL TÊTREAU

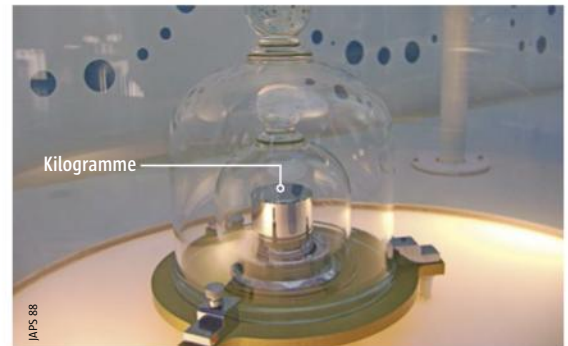
## DRONES WILL SAVE ENDANGERED KOALAS

The number of koalas is plummeting, and today, there are fewer than 100,000 left. As part of the effort to save the endangered species, scientists use heat-seeking cameras to find out where the iconic marsupials live.

SHUTTERSTOCK &amp; ANTHONY WEATE/OUT

## 9.3 million

length, in digits, of the most recently discovered prime number. Yet this number, which is divisible by 1 and itself, is only the seventh-largest prime known.



Today, 1 kg is defined by a physical weight, but in the future, a natural constant will define the unit of weight.

## Our units of measurement become more accurate

**PHYSICS** From late 2018, one kg will no longer be the same as it is now. Our system of measurement is to be renewed, and four units will be redefined to become as accurate as possible. The four units are kg (weight), ampere (electric current), kelvin (temperature), and mole (amount of substance).

Kg is defined based on a "kilogramme" prototype made of a platinum iridium alloy, but over time, this lump has become heavier. So, a kilo will be redefined based on the Planck constant - which does not change.

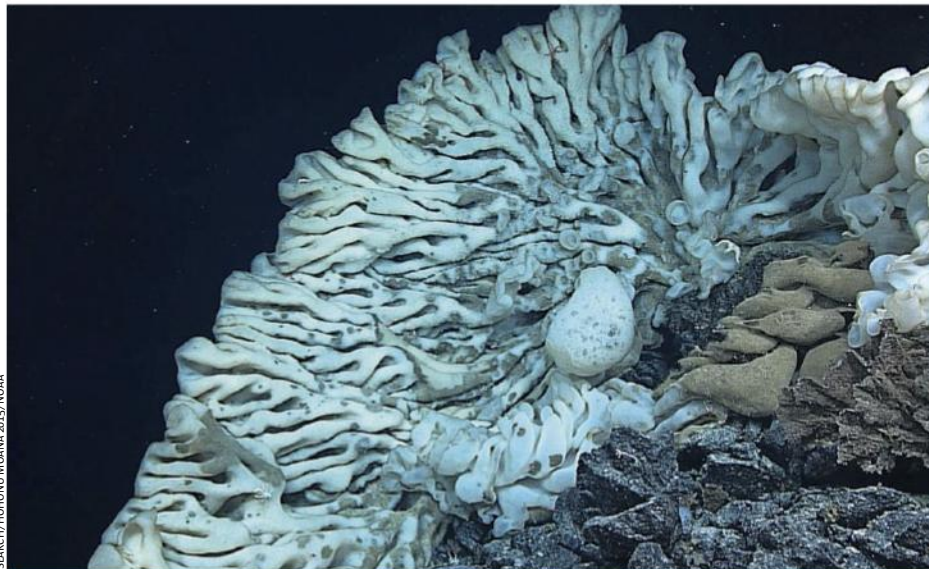
### ENCYCLOPEDIA

**SI:** The "international system" that includes seven basic units: metre, kilogramme, second, ampere, kelvin, mole, and candela.





## LOCAL FOCAL POINT – Pacific Ocean



### The world's oldest animal is the size of a car

In the ocean off Hawaii, at a depth 2000 metres, you can find a sea sponge that is 3.5 m long, 2 m tall, and 1.5 m wide - as large as a car. According to scientists, the huge organism is probably the oldest animal on our planet, as it could be more than 2,000 years old.

OFFICE OF EXPLORATION AND RESEARCH/HONOLULU HONOLULU 2015/NOAA

# > 2.52-billion-

**year-old bacteria fossils** have been found in South Africa. When they lived, there was no oxygen, so maybe life could exist on planets without oxygen. They needed water though!

## Rivers of methane flow in canyons on Titan

**ASTRONOMY** Saturn's moon Titan is crisscrossed in deep and steep canyons carved by rivers of liquid methane, according to data from the Cassini probe.

The canyons are 244-579 m deep, up to 800 m wide, and slope up to 40 degrees. They are very much like canyons on Earth such as the Grand Canyon in Arizona.

The similarities between Earth and Titan, which are very different worlds, are a surprise to the scientists behind the discovery. Whereas Earth is warm and rocky and has rivers of water, Titan is cold and icy and has rivers of methane.

Scientists still do not know how the canyons formed, but they are probably the results of a long geological process, during which the landscape rose.



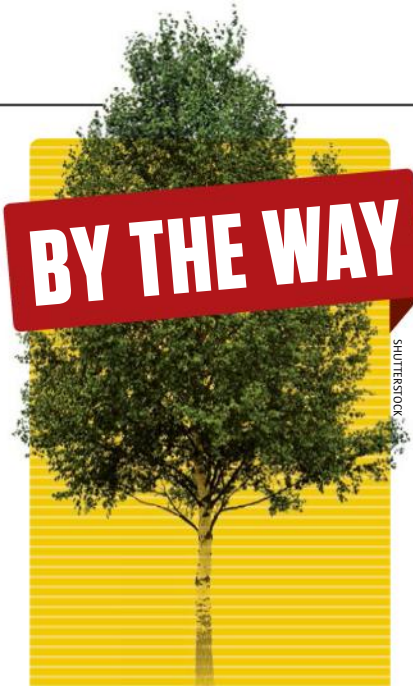
Saturn's moon, Titan, includes deep canyons much like the Grand Canyon in the US.

NASA

### TITAN IS AN ICE WORLD

- **Giant:** Titan is Saturn's largest moon.
- **Dense air:** Titan's atmosphere is denser than Earth's.
- **Ice world:** The surface temperature is  $-180^{\circ}\text{C}$ , and the moon is reminiscent of a young Earth.

## BY THE WAY



SHUTTERSTOCK

### NEWS FLASH!

Just like humans, trees have a circadian rhythm and rest during the night, according to laser scans showing the branches of a 5-m-tall tree hang 5-10 cm lower at night - and not because of wind.

### And speaking of trees ...

- A tree can grow a maximum of 130 m tall.

The laws of physics set a limit to the growth: Gravity affects the water, as it rises through the trunk, and sooner or later, the tree will be so tall that gravity wins.

- The world's tallest tree species is redwood, which can grow up to some 115 m high. The lowest tree species, dwarf willow, only rises 6 cm into the air.

- On a hot summer's day, approximately 1,500 litres of water evaporate from a large oak, corresponding to about 11 bathtubs.



## Screws hold prosthesis in place

**By means of magnets and titanium screws, the cheap prosthesis is better anchored than traditional prostheses.**

**1** The doctor takes photos of the face with a smartphone, and subsequently, the Autodesk 123D Catch app converts the photos into a 3D model. The healthy side of the face is reversed, and the prosthesis is digitally shaped to fit.

**2** A silicone prosthesis is printed by a relatively cheap standard 3D printer.

**3** Primer, skin colour, texture, and wrinkles are applied for the prosthesis to look natural.

**4** Magnets are used to anchor the prosthesis to three titanium screws in the skull. The prosthesis can easily be removed and cleaned.



# Smartphone and 3D printer provide man with new face

**By means of easily accessible technology in the shape of a smartphone app and a 3D printer, scientists can create a lifelike and cheap face prosthesis.**

**TECHNOLOGY** A Brazilian man, who survived cancer, has been provided with a face prosthesis that was created by means of a smartphone app and a 3D printer.

In 2008, Carlito Conceição was diagnosed with a very aggressive type of mouth cancer, but after life-saving surgery, in which doctors managed to remove the fast-growing tumour, the former salesman's face included a gaping

hole in the place where his right eye, cheek-bone, and part of the nose used to be. The facial prosthesis that Conceição was subsequently equipped with, caused him lots of problems because it kept falling off, and in the end, Conceição hardly dared to leave his house, developing severe depression.

Conceição's salvation was a new and cheap treatment that was developed by

scientists at São Paulo's State University. Using a free app that can convert photographs into 3D models, which can subsequently be printed, Conceição has been equipped with a new silicone prosthesis. Apart from being cheap, the prosthesis is very lifelike and easy to put on and take off. It is anchored with magnets that attach to screws in his skull.

## ODD ROCK TURNED OUT TO BE DINO BRAIN

For the first time ever, scientists have a dinosaur brain fossil. It was discovered in Sussex, England, in 2004, but it was only recently that palaeontologists used an electron microscope to study the fossil. The brain probably comes from a large herbivore such as the iguanodon, that lived 133 million years ago.





**> 482.8 km**  
is the distance covered by a BAE System pilotless plane as it flew between Lancashire and Inverness in the UK.

**SHOOTING STAR** – Recognise Jupiter?



**Clouds and severe storms ravage Jupiter's south pole**

From its orbit around Jupiter, NASA's Juno probe has sent spectacular images back to Earth. Heavy weather with turbulent clouds and white ovals that are severe storms with wind speeds of up to 350 km/h characterise the view of the gas planet's south pole. Like the north, there are no bands.

NASA



**SMALL BIRD REMAINS FLYING FOR ALMOST A YEAR**

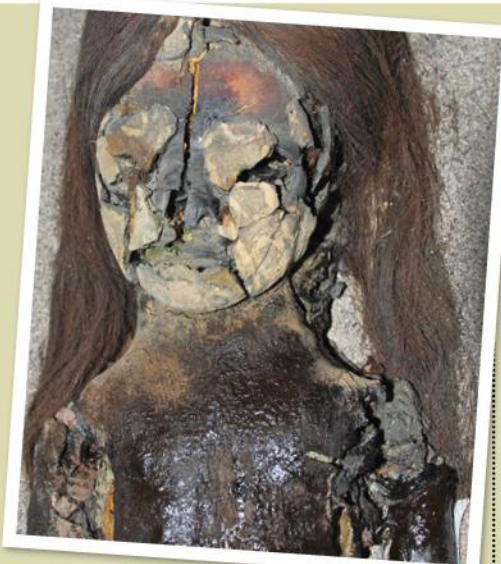
The common swift can remain flying for 10 months at a time, according to research carried out by the Lund University in Sweden. Biologists have confirmed the record by placing sensors on 13 of the small birds, registering their patterns of movement for up to two years. The birds only land to breed and lay eggs.

SHUTTERSTOCK

**Bacteria consume ancient mummies**

**ARCHAEOLOGY** A collection of ancient human bodies from the archaeological museum in the Chilean city of Arica is oozing away. The bodies were naturally mummified by drying in the hot desert climate of northern Chile, but due to high air humidity caused by climate change, 100 of the mummies are being consumed by bacteria, which feast on their skin, converting them into a black, jelly-like substance.

Scientists, who have not encountered the phenomenon before, do not know how to stop the decay of the 7,000-year-old Chinchorro mummies. The local authorities hope that UNESCO will make the mummies world heritage, so they can obtain the expertise and the money necessary to preserve the mummies.



The world's oldest mummies may turn into black slime due to humidity and heat.

**THE DEAD WERE HIDDEN IN THE SAND**

The barren land strip between the Pacific Ocean and the hot Atacama Desert in Northern Chile and Southern Peru was the home of the Chinchorros, and 7,000+ years ago, they began to make mummies by drying their dead.



VIVIAN STANDEN/UNIVERSIDAD DE TARAPACA



— Washington Post

# BRIAN GREENE

# A TIME TRAVELLER'S TALE

*Take a remarkable journey into a hidden reality far more fascinating than anything we could have imagined.*

**MARCH 2017** SYDNEY / MELBOURNE / AUCKLAND

    @THINKINCAU #THINKGREENE



**THINK INC.**  
smart answers to BIG questions



## NEWS FLASH!



### Women sent Vikings travelling

Polygamy was common among wealthy Vikings, but as a result, the remaining men had fewer women to choose from, and so, they went to find wives in other places, according to new research.

## Cannabis improves night vision

**MEDICINE** Cannabis is about to become a new wonder drug. The active ingredients of the infamous plant have turned out to have the potential to relieve a long series of diseases, from cancer to epilepsy, and now, animal experiments by the Montreal Neurological Institute in Canada indicate that cannabis also benefits vision. In tadpoles, cannabinoids, increase the activity of the retina cells, which become more sensitive to light.

It remains unclear, whether the effect is the same in humans, but there is evidence to suggest it. Previously, scientific studies from both Morocco and Jamaica have demonstrated that local mountain peasants and fishermen get markedly improved night vision after consuming cannabis.



Test animals get better night vision after consuming cannabis, according to new research.

SHUTTERSTOCK

# Go diving in the virtual world

Virtual reality simulators allow you to explore the oceans without getting one single drop of water on your body.

**TECHNOLOGY** Are you scared of water? If so, the Amphibian virtual reality simulator can provide you with a very lifelike experience of how it feels to swim in the abyss by fooling several of your senses.

The simulator, that was invented by a computer scientist from the MIT Media LAB in the US, involves several senses, as it takes the user into the deep. Arms and legs are suspended in elastic harnesses connected to motion sensors. The elastic harnesses create

an illusion of water resistance and weightlessness in the user. A snorkel device registers breathing and passes the data on to the cushion on which the body rests. As you breathe, the cushion rises, and as you exhale, the cushion falls - the user is rising and falling in the same way as if he were on a real diving expedition.

The experience of being in the water is completed by the VR goggles that introduce a lifelike 3D ocean "landscape".

Amphibian appeals to all emotions, taking you on a realistic expedition into the ocean.

## Gloves regulate the temperature

The VR simulator boosts the submarine experience by regulating the temperature via gloves that include cooling units and register how low you go.

**SEE:** The diving mask is replaced by VR goggles. As you move through the water, you can see your hands and air bubbles rising towards the surface.

**WATER RESISTANCE:** Elastic harnesses affect your arms and legs, providing resistance as you move through the water.

**HEAR:** Sounds are distorted under water, and the earphones provide you with the "mumble" of the deep.

**FREEZE:** Cooling units attached to the gloves make sure that the temperature falls as you go deeper.

**LIFT:** When you breathe through the snorkel, air is pumped into the cushion on which you lie, making your body rise and fall slightly. Springs provide the motion.

JAMES DRY/MIT & SHUTTERSTOCK



# The Foundation for the Advancement of Astronomy supporting excellence



The Foundation for the Advancement of Astronomy, established by the Astronomical Society of Australia, recognises excellence through the Society's activities.

- **The Bok Prize** for outstanding research by an Honours/Masters student
- **The Charlene Heisler Prize** for most outstanding astronomy PhD thesis
- **The Louise Webster Prize** for excellence by an early career researcher
- **The Ellery Lectureship** for outstanding contributions in astronomy
- **The David Allen Prize** for exceptional astronomy communication
- **The Berenice & Arthur Page Medal** for excellence in amateur astronomy
- **The Richard Cole Fund** to support training for postgraduate students

## Donate to the Foundation for the Advancement of Astronomy

ABN: 37 660 297 848

[asa.astronomy.org.au/FAA](http://asa.astronomy.org.au/FAA)

Amount A\$: ☐ \$25 ☐ \$50 ☐ \$100 ☐ \$200 Other: \_\_\_\_\_

Preferred prize/activity to support (not compulsory): \_\_\_\_\_

Cheques payable to "Foundation for the Advancement of Astronomy"

Credit Card Payments: ☐ Mastercard ☐ Visa

Card Number \_\_\_\_\_ / \_\_\_\_\_ / \_\_\_\_\_ / \_\_\_\_\_ Expiry Date \_\_\_\_ / \_\_\_\_

Cardholder Name \_\_\_\_\_ Date \_\_\_\_\_

Cardholder signature \_\_\_\_\_



Donations of \$2 or more are tax-deductible for Australian residents. Donors can choose to select which Foundation activities they would like to support. The Foundation exists through the support of Australian astronomers and the general public. Please submit your payment to the ASA Treasurer, Dr Katrina Sealey c/- Australian Astronomical Observatory, PO Box 915, North Ryde, 1670, NSW.

# Astronomical Society of Australia Inc

The organisation of professional astronomers in Australia [asa.astronomy.org.au](http://asa.astronomy.org.au)



## Do soap bubbles have colours?

How can soap bubbles be both transparent and seemingly incorporate all the colours of the rainbow?

A soap bubble has many colours, because the light is reflected at several angles, when it hits the bubble's special structure.

A soap bubble consists of two layers of soap molecules with water in between. Inside and around the bubble, there is air. When the light hits the external layer of molecules, it is

either reflected immediately or continues to the internal layer, where it is reflected instead. As the light hits the bubble's two layers, it is sent back at the same angle, and the two light beams will either intensify or erase each other. The interaction between the rays determines the colour of the bubble.

### Light beams affect each other

The play of the light depends on a bubble's thickness and the angle of the light. The longer a soap bubble exists, the weaker its colours become, as the water layer around it gets thinner. Right before a soap bubble bursts, it is more or less colourless.

#### Layered soap bubbles

The exterior of a soap bubble is a thin water layer surrounded by two layers of soap molecules.

**When the light hits a bubble,** it is reflected by both the internal and the external soap layer.

Light waves

#### Rays are cancelled

If the waves of the two light beams are totally opposite, they cancel each other, producing **destructive interference**.

External soap layer

Internal soap layer

### HOW ARE SCRATCH TICKETS MADE?

A scratch ticket is a piece of cardboard that typically consists of 20+ layers subdivided into different colours, numbers, and symbols. The top layer is the scratch silver, which you must remove to see if you won. The many layers prevent you from seeing what is hiding in the scratch field, even if you hold the ticket up against bright light.

MURDEN





## TOP 5

Which animal stock-piles the most food?



1

**BEAVER**

200-2,000 kg twigs + branches. The food is hidden **on lake floors**, where the beaver lives. The cold water keeps the food fresh.

2

**ACORN WOODPECKER**

150-200 kg of acorns. Individual acorns are hidden **in cavities** or in thousands of small holes in special tree trunks.

3

**SQUIRREL**

20-50 kg of nuts and cones. The food is placed **in forest floor deposits**. If the squirrel forgets some, new trees grow up.

4

**BLUE JAY**

20-30 kg of nuts. Individual nuts are hidden in deposits **throughout the wood**, in the ground and in branches.

5

**WATER VOLE**

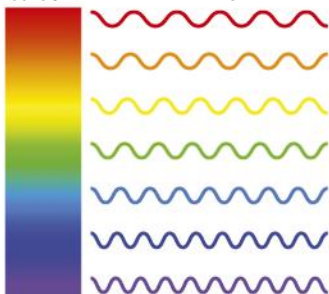
10-35 kg of potatoes and roots. The food is typically stored **in an excavated burrow** or in a hollow tree trunk.

**Beams intensified**

If two light beams of the same frequency encounter, they intensify each other, producing **constructive interference**.

Light waves

COLOUR WAVE LENGTH

**The colour depends on light waves**

The colour of an object is determined by the colours it absorbs and reflects.

In a light beam, the distance between two wave peaks determines the colour of the light. Red light has a wavelength of 625-740 nm, whereas blue light has wavelengths of 450-500 nm. White light is a mixture of all visible colours.

## SPACE-SAVVY?

**How do astronauts pee?**

Astronauts who need to pee use a funnel attached to a long plastic tube. Pressure inside the tube causes the urine to be sucked in the right direction to be collected. The astronaut urine is either left in space or cleansed and reused as drinking water. The system works for men and women.

**Does ice get stronger, the colder it is?**

The colder ice is, the greater its bending strength and the more weight it can carry. The increased bending strength is due to the fact that bindings between the water molecules of the ice's crystal lattice improve, whereas the links between individual ice crystals are also improved with lower temperatures.

However, ice strength also depends on several other factors. The thickness of the ice is vital for how many people the ice of a lake can carry, before it breaks. Elements inside the ice also play a role. Sea ice often includes tiny pockets of concentrated salt water that make it weaker than fresh water ice of the same thickness and temperature.



Sea and lake ice becomes stronger, when temperatures fall.



## Can butterflies lose their ability to fly if I rub the dust from their wings?

The story that butterflies lose their ability to fly, if you rub the dust off their wings, is very common, but not true. The fine dust of the wings is really small, coloured scales that provide butterflies with their beautiful patterns and colours. The scales have no influence on a butterfly's flying capacity. Butterflies often become "shabby" and develop "bald" spots on their wings at the end of the season. In Australia, you can observe that most butterfly species lose some of their dust and look shabby in late summer and early autumn.

### NOT ALL INSECTS NEED WING-DUST

#### Species with dust:

The "dust" on the wings of butterflies consists of small, flat and hollow converted hairs that stick to the wing surface as scales.

#### Species without dust:

Most other insects have large, clear areas on their wings and so no scales. But they are still able to fly.



SHUTTERSTOCK

Butterflies can easily fly without the small scales on their wings.



### INSIDE THE BODY

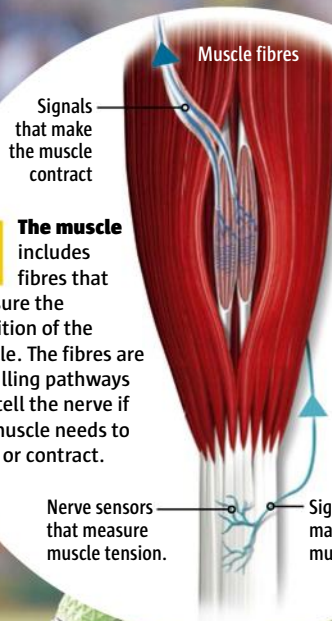
## What are cramps?

Most people have experienced painful cramps in calves or thighs. Cramps occur when the muscles suddenly contract sharply, and they can last for anything from a few seconds to several minutes. The condition typically arises during and after physical exercise and occurs more often with age.



**1** The spinal cord includes nerves that order the muscles of the calf to either relax or contract. The nerves are controlled by willpower and reflexes, but also by sensors in the muscle.

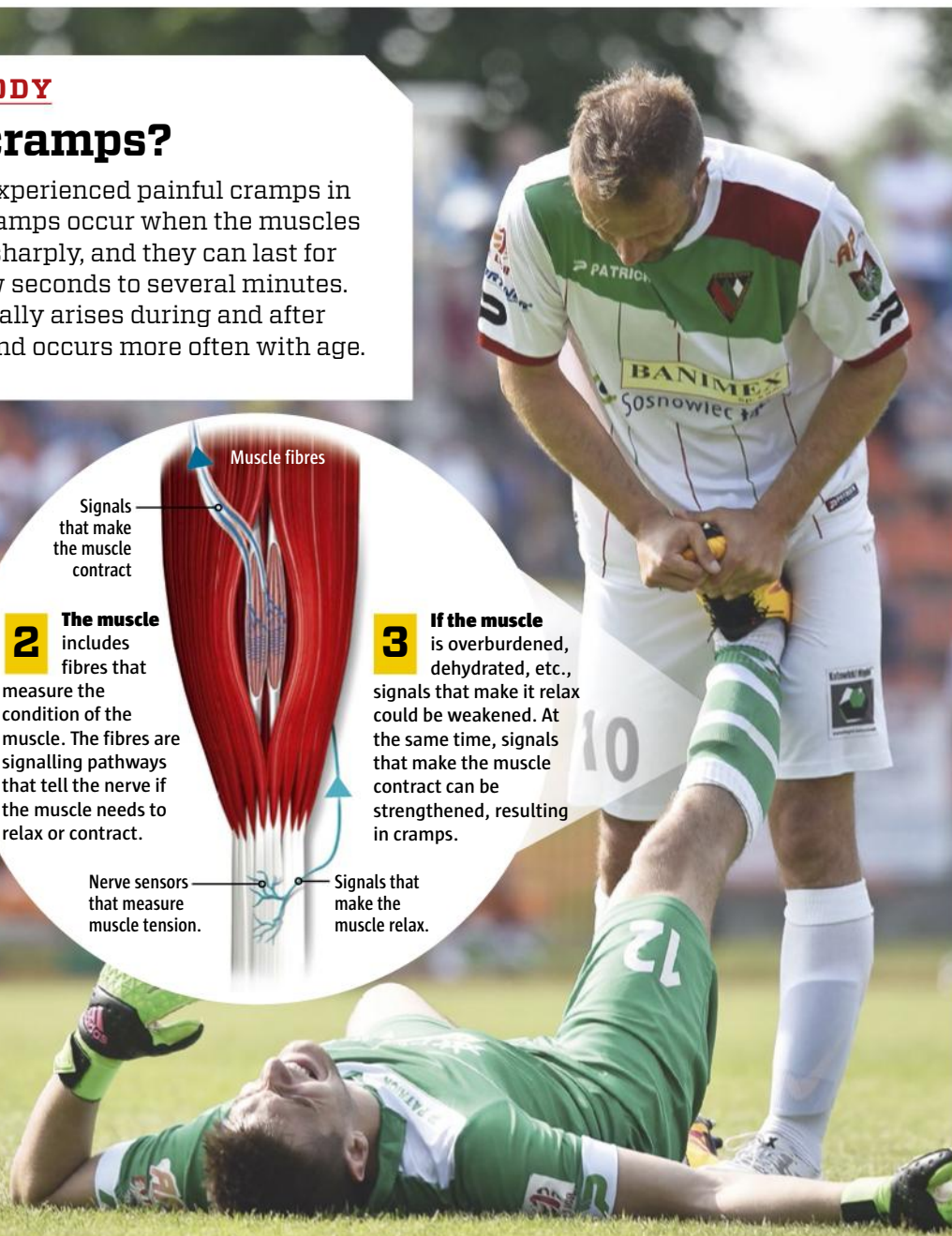
**2** The muscle includes fibres that measure the condition of the muscle. The fibres are signalling pathways that tell the nerve if the muscle needs to relax or contract.



**3** If the muscle is overburdened, dehydrated, etc., signals that make it relax could be weakened. At the same time, signals that make the muscle contract can be strengthened, resulting in cramps.

Signals that make the muscle relax.

If you overwork your muscles, you are more likely to get cramps.



SHUTTERSTOCK OG-HENNING DALHOFF



From 2018, the **James Webb** telescope will photograph exoplanets.

The Gemini telescope in Hawaii uses a laser beam to create an artificial star in the sky that helps astronomers photograph exoplanets.

# Is it possible to photograph an exoplanet?

Only the largest telescopes of all can photograph planets orbiting other stars than the Sun, and that is what exoplanets do. Even the closest ones are billions of km away, and their faint light is very difficult to capture for a camera.

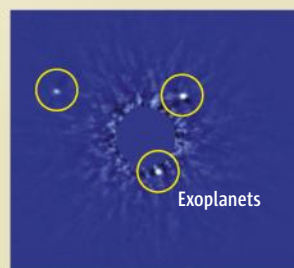
Exoplanets do not emit light themselves, rather they reflect a little of the light from their star. Today, astronomers can only photograph large exoplanets orbiting far away from their

star. They must be larger than Jupiter and so far away from their star that their light is not drowned out by the star's light.

In 2008, we managed to photograph exoplanets for the first time. By means of the huge Gemini and Keck telescopes in Hawaii, Canadian and US astronomers spotted no less than three planets around the HR8799 star. Since then, a fourth exoplanet orbiting the star has also been captured in images.

## BRIGHT DOTS REVEAL PLANETS

Three exoplanets can be seen as small dots around the HR 8799 star in the below image from 2008. A special instrument blocks out the light from the star, making the planets appear.



SHUTTERSTOCK



## WORLD RECORDS

### The place with the most birds?

The Colombian rain forest is the home of lots and lots of birds that are not observed anywhere else in the world. The country is popular among ornithologists, as the number of species is

# 1,876

### COLOMBIA

**Where:** The rain forests of South America

**What:** The most bird species in the world



GETTY IMAGES



## Should roses be placed in warm water?

According to a piece of good advice, roses should be placed in warm water, but it is not supported by scientific evidence. Most cut flowers thrive in cool conditions and in cold water. On the other hand, the powder that is often sold with flowers is dissolved more efficiently in warm water. It contains antibiotic substances that kill bacteria.

It is a good idea to cut the stalks under water, so no air enters. Flowers absorb water via internal water "pipes" in the stalks, and if they "inhale" air, air pockets or "plugs" form, preventing water from reaching the heads. Roses, lilacs, and sunflowers have wood-like or branchy stalks with large vessels. They produce air pockets faster, making the heads wither.

SHUTTERSTOCK



Roses and other cut flowers last longer, if you place them in cold water and under cool conditions.

**How much blood does the human heart pump?** Your heart pumps blood to your entire body, supplying all your organs with oxygen and nutrients. Every day, the average adult person's heart pumps

# 9,000+ litres



## WHAT IS THIS?



INTEL

Brine shrimp are tiny crustaceans that tolerate lots of salt. So, they thrive in salt lakes that are as much as 8-10 times saltier than sea water.

■ Brine shrimps are often the only animal species in tropical salt lakes. They have almost no enemies and can grow so numerous that they sometimes colour the water pink.

■ Brine shrimps produce small, circular cysts, if the salt lake runs dry. The cysts are particularly durable eggs that can remain between salt crystals for years.

■ If the cysts enter water, they quickly develop into new creatures. The eggs are so durable that they can be sent by mail, so they are used for fish feed, etc.



Wind turbine wings produce noise when they rotate.

### DENMARK LEADS THE WIND POWER RACE

In 2015, 42 % of the Danish power consumption was covered by wind turbines. So, Denmark is the country that generates the most wind turbine power per capita.

Top 5 wind power-generating nations (per capita):

- Denmark
- Sweden
- Spain
- Ireland
- Germany

Is it really true that ...

# ... wind turbines make me sick?

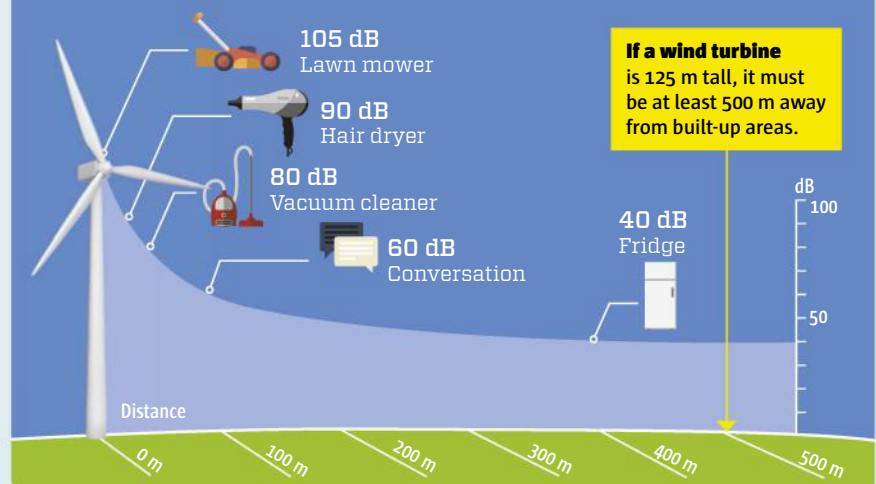
When a 60-m-tall wind turbinespins at 150 km/h, it produces noise. Some neighbours claim this noise affects their health. Wind turbines emit low-frequency noise (10-160 Hz) and infrasound (4-20 Hz). The sounds that people can hear are normally 50-12,500 Hz.

Several studies have shown that both the infrasound and low-frequency noise made by wind turbines are much lower than the limit values set by countries including Australia. In 2014, scientists from MIT in the US published a comprehensive study of wind turbines' effect on our health. The scientists concluded that the noise does not affect our health directly. And turbines are usually quieter than trucks passing on nearby roads.

Perhaps the most compelling evidence that turbines are innocent? People claiming ill effects often still experience them... even when the turbines are switched off.

## A wind turbine does not whisper

Turbines are loud. Up close, as loud as a lawnmower, but at a distance of 100 m, the noise has been reduced so much that the sound of the turbine is like that of a normal conversation. Beyond 500m only very low "infrasound" can be detected. And even then, not much.





# Water flows in our Solar System

According to new images from the Hubble telescope, a huge ocean flows beneath the ice crust of Jupiter's moon Europa. So, the list of possible water planets includes 12, and the chances of finding life are markedly improved.

NASA




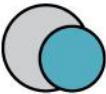




## EARTH'S WATER IS A PUDDLE

Several Solar System worlds probably include much more water than Earth.

Planet	Planet	Dwarf planet	Jupiter's moons		
<b>EARTH</b>	<b>MARS</b>	<b>CERES</b>	<b>EUROPA</b>	<b>GANYMEDE</b>	<b>CALLISTO</b>
Radius: 6,371 km Water: 1,386 million km <sup>3</sup>	Radius: 3,390 km Water: Quantity unknown	Radius: 473 km Water: Quantity unknown	Radius: 1,565 km Water: 2,854 million km <sup>3</sup>	Radius: 2,631 km Water: 54,361 million km <sup>3</sup>	Radius: 2,410 km Water: 24,429 million km <sup>3</sup>





Saturn's moons				Neptune's moon	Dwarf planet
					
<b>MIMAS</b>	<b>TITAN</b>	<b>ENCELADUS</b>	<b>DIONE</b>	<b>TRITON</b>	<b>PLUTO</b>
Radius: 198 km Water: Quantity unknown	Radius: 2,576 km Water: 28,280 million km <sup>3</sup>	Radius: 252 km Water: 44 million km <sup>3</sup>	Radius: 561 km Water: 463 million km <sup>3</sup>	Radius: 1,352 km Water: 6,709 million km <sup>3</sup>	Radius: 1,187 km Water: 4,316 million km <sup>3</sup>



**A**n ice crust which is several kilometres thick wraps Jupiter's moon Europa in a greyish brown, scarred, and rock-hard armour with temperatures as low as  $-220^{\circ}\text{C}$ , and the moon leaves an impression of a hostile ice kingdom, from which living creatures should stay far away.

However, several cracks in the ice regularly allow high columns of water vapour to escape into space, according to new images from the Hubble space telescope, which has observed the small moon for 15 months. The columns are probably liquid water, which forces its way up through the cracks in Europa's ice crust, evaporating as it encounters empty space. According to the astronomers behind the study, the columns are evidence that the moon includes an ocean beneath the ice crust, which holds twice as much water as Earth.

The discovery is just one of a series made during the past year, which have shown that several Solar System worlds include kilometre-deep underground oceans – and hence could include life.

## ASTRONOMERS FOLLOW THE WATER

When the American space agency NASA searches for life in space, it works according to the "Follow the water" mantra. On Earth, biologists have found living organisms anywhere, where liquid water is present, and astronomers hope that the same is true for other worlds.

Water is liquid at temperatures that make places bearable to stay in for living organisms. Moreover, liquid water is an excellent solvent that helps nutrients along to cells. So, liquid water combined with salts and minerals is the perfect basis of life. And if energy is also present, astronomers become very interested indeed.

Thanks to numerous unmanned probes and telescope observations, the list of Solar System worlds that could include liquid water has grown fast since the 1990s. Today, the list includes 12 planets, dwarf planets, and moons that do not only vary very much in size, but are also spread across the entire Solar System. Astronomers are almost sure that two of Jupiter's moons, Ganymede and Europa, and Saturn's moon Enceladus include liquid water, but its existence has not yet been finally proved.

Paradoxically, astronomers consider three moons that orbit Jupiter and Saturn the most likely to include liquid water in our Solar System. Like their planets, the three ice moons are located at quite a distance from the Solar System's habitable zone, where temperatures are high enough to ensure the existence of liquid water.

## JUPITER DOMINATES ICE MOON

Astronomers have long been particularly interested in Europa, which is the size of Earth's moon and so the smallest of Jupiter's four large moons. And the new images from the Hubble space telescope very much confirm that the moon includes water.

A team of scientists headed by astronomer William Sparks from the Space Telescope Science Institute in Baltimore, USA, used a method that is normally used to reveal whether a planet orbiting a foreign star has an atmosphere. For 15 months, the space telescope observed Europa, as it passed in front of Jupiter, allowing Hubble to photograph the moon with Jupiter in the background.

The images revealed irregularities on Europa's surface, which blocked out Jupiter's light at regular intervals. According to astronomers, the irregularities are 200-km-high steam columns, which occur, when liquid water forces its way up through cracks in the moon's ice crust, evaporating as it encounters empty space.

Europa enters into a brutal relationship with Jupiter, with the latter as the dominant partner. Weighing 318 times more than Earth, Jupiter is the largest planet in our Solar System, and the huge mass means that it is constantly affecting the moon. The scenario can be compared with a cherry that is squeezed between two fingers.

The stone at the centre of the cherry is Europa's hard core, and the flesh is the water, whereas the skin is the ice crust. When the fingers squeeze the skin, it bursts, allowing the juice from the interior of the cherry to escape. According to scientists, that is what happens, when geysers send a several hundred-km-high steam column into empty space. The process leaves so much energy in Europa that the water, that should have been frozen, melts and becomes liquid a few km below the external ice crust.

Astronomers have calculated that Jupiter's gravitational pull on Europa is so forceful that the tide beneath the ice crust differs by 200 m between ebb and flow. And that is only possible if there is liquid – and not ice – beneath Europa's external ice crust.

The discovery of geysers on Europa confirms a similar study from 2012, and the new, stronger indications that the moon includes an underground ocean is good ►

## 1 SWAYING CRAFTS

A spacecraft's orbit around a world is not a perfect circle, as **gravitational field changes affect the craft's speed and path**. Based on the minor irregularity, astronomers can calculate the make-up of the world and see, if it includes the ingredients of water, etc.

## 2 SLUGGISH NEUTRONS

When cosmic radiation hits the surface of a world, the result is a cloud of particles, including neutrons. **As hydrogen makes neutrons sluggish, astronomers can reveal the existence of hydrogen – and perhaps of water at depths of down to 10 m – by measuring the speed of the neutrons emitted from the surface.**



# Seven signs of water

When astronomers look for liquid water in the Solar System, they focus on seven physical characteristics, which indicate the existence of water in the remote, hostile worlds.

## 3 CHANGING TEMPERATURES

The surface temperature of a world can reveal whether it includes liquid water. **If an area includes water, the surface will heat up and cool more slowly** than areas without water. Astronomers can measure the surface temperature by means of an infrared camera.

## 4 FLEXIBLE WORLDS

**If a world is very flexible, changing shape, it is an indication of the existence of liquid water**, as a solid interior would not easily change shape. Love numbers indicate the elastic response of a world, and they are found by observing the world and registering the displacement of mountain peaks, etc. If the numbers are sufficiently high, the world may include an ocean.

## 5 COMPLEX CALCULATIONS

**Computer simulations can reveal, whether a world's water is liquid or frozen.**

Based on the world's surface temperature, size, and the gravitational pull of other worlds, astronomers can make a computer model that shows the water content over time.

## 6 GEYSER CHEMISTRY

**Huge columns of steam escaping thick ice caps are an indication of liquid water.** Astronomers find out if the geysers contain water by looking for evidence of hydrogen and oxygen. The two can be observed in ultraviolet images from a telescope.

## 7 ALTERNATING MAGNETIC FIELD

**A world's external magnetic field can create a reversed magnetic field in the water.**

If a moon shows signs of a reversed magnetic field in comparison to the planet it is orbiting, there may be an ocean beneath the moon's surface.



news for astronomers, as it means that a robotic probe needs not force itself down through Europa's ice crust to find water, it can be done by a spacecraft.

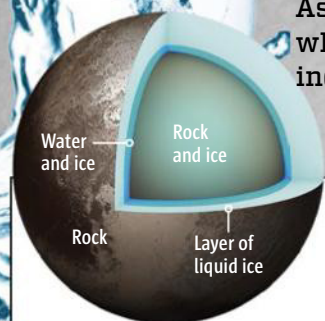
## MARTIAN SOIL AS DRY AS A DESERT

Astronomers are not only looking for water far away in the Solar System, the search has also begun on our neighbouring planet, Mars, but the results are not as good.

According to astronomers, Mars could have been just as wet as Earth some four billion years ago, but the planet's magnetic field, which protects against radiation from the Sun, is much weaker than Earth's, and so,

# Five worlds could include living creatures

Astronomers are relatively sure that five Solar System worlds include water, in which living creatures could thrive. Apart from three ice moons, the list also includes some of the most prominent members of the Solar System.



## PLUTO

### Salt water ocean surprises scientists

The dwarf planet of Pluto has long been considered to be a dead world, but new data from the New Horizons mission indicates the opposite. Pluto's surface is an icy mixture of frozen water, nitrogen, and methane, and scientists have seen signs of surface expansion. Consequently, Pluto could include water that is freezing.

**Type:** Dwarf planet  
**Radius:** 1,187 km  
**Water:** 4,316 million km<sup>3</sup>  
**Life:** Unknown

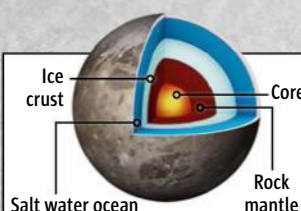


## MARS

### Water leaves dark traces

Mars includes large quantities of ice at its poles, and geological evidence indicates that the planet's surface once included lakes, oceans, and rivers. In 2015, NASA interpreted dark traces on the surface to be liquid water, but if so, there was very little water. The water has disappeared, because solar wind breaks down the atmosphere.

**Type:** Planet  
**Radius:** 3,390 km  
**Water:** Quantity unknown  
**Life:** Perhaps

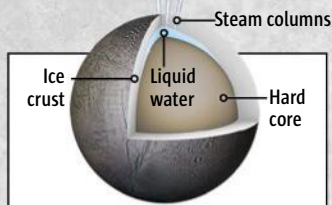


## GANYMEDE

### Huge ocean hiding beneath the ice

Our Solar System's largest moon, Ganymede, is so big that it has its own magnetic field, which astronomers have used to reveal that the moon probably includes a large salt water ocean beneath the icy surface. Aurora observations have shown that the two of them do not move as much as they would, if the moon were completely solid.

**Type:** Moon  
**Radius:** 2,631 km  
**Water:** 54,361 million km<sup>3</sup>  
**Life:** Probably



## ENCELADUS

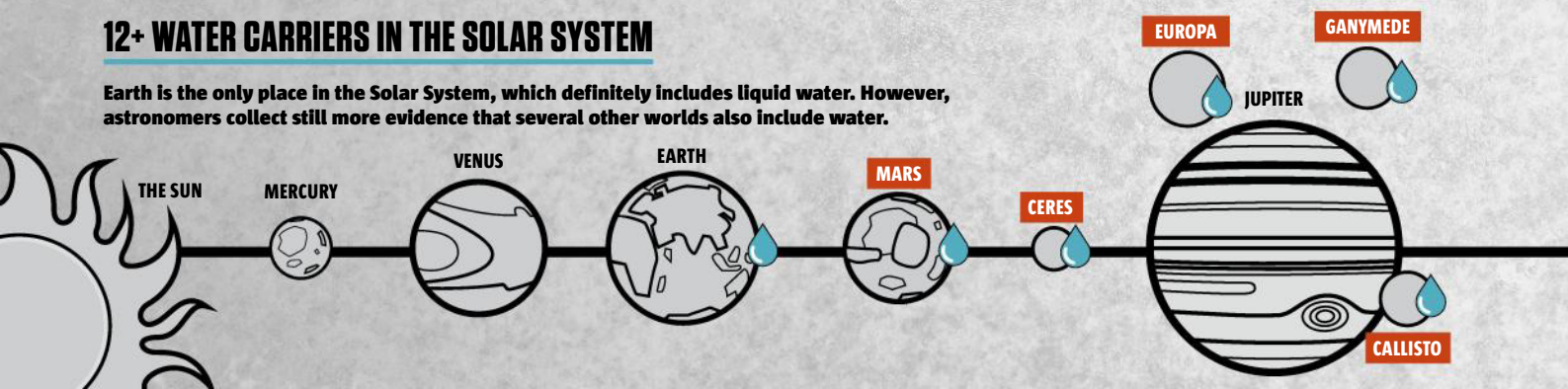
### Small moon includes geysers

Saturn's Enceladus moon probably hides a liquid ocean beneath its ice crust, and from the moon's south pole, up to 500-km-high steam columns are ejected at speeds of up to 1,800 km/h. The ocean was spotted by means of gravity data from NASA's Cassini probe in 2005 and has since been confirmed by flying through the geysers in 2015.

**Type:** Moon  
**Radius:** 252 km  
**Water:** 44 million km<sup>3</sup>  
**Life:** Perhaps

## 12+ WATER CARRIERS IN THE SOLAR SYSTEM

Earth is the only place in the Solar System, which definitely includes liquid water. However, astronomers collect still more evidence that several other worlds also include water.





the planet's atmosphere has become considerably thinner. In 2015, NASA's MAVEN probe revealed that the constant solar wind particle bombardment removes 100 g of gasses from the atmosphere per

second. Hence, Mars could not retain liquid water, and water now only exists in the shape of underground ice. ▶

## EUROPA

# Moon includes twice as much ocean as Earth

**A**stronomers in 2016 found strong indications that there is a huge ocean of liquid water beneath the ice crust of the Europa moon, which is orbiting Jupiter.

The up to 200-km-high steam columns that burst through the ice of Europa make the geysers on Earth look like tiny squirts. The

combination of water, salts, minerals, and energy from Jupiter's gravitational pull makes Europa an obvious place to look for life in the Solar System.

**Type:** Moon  
**Radius:** 1,565 km  
**Water:** 2-3 times Earth's  
**Life:** Probably

## HOW HUBBLE DISCOVERED WATER

### 1. OBSERVATION

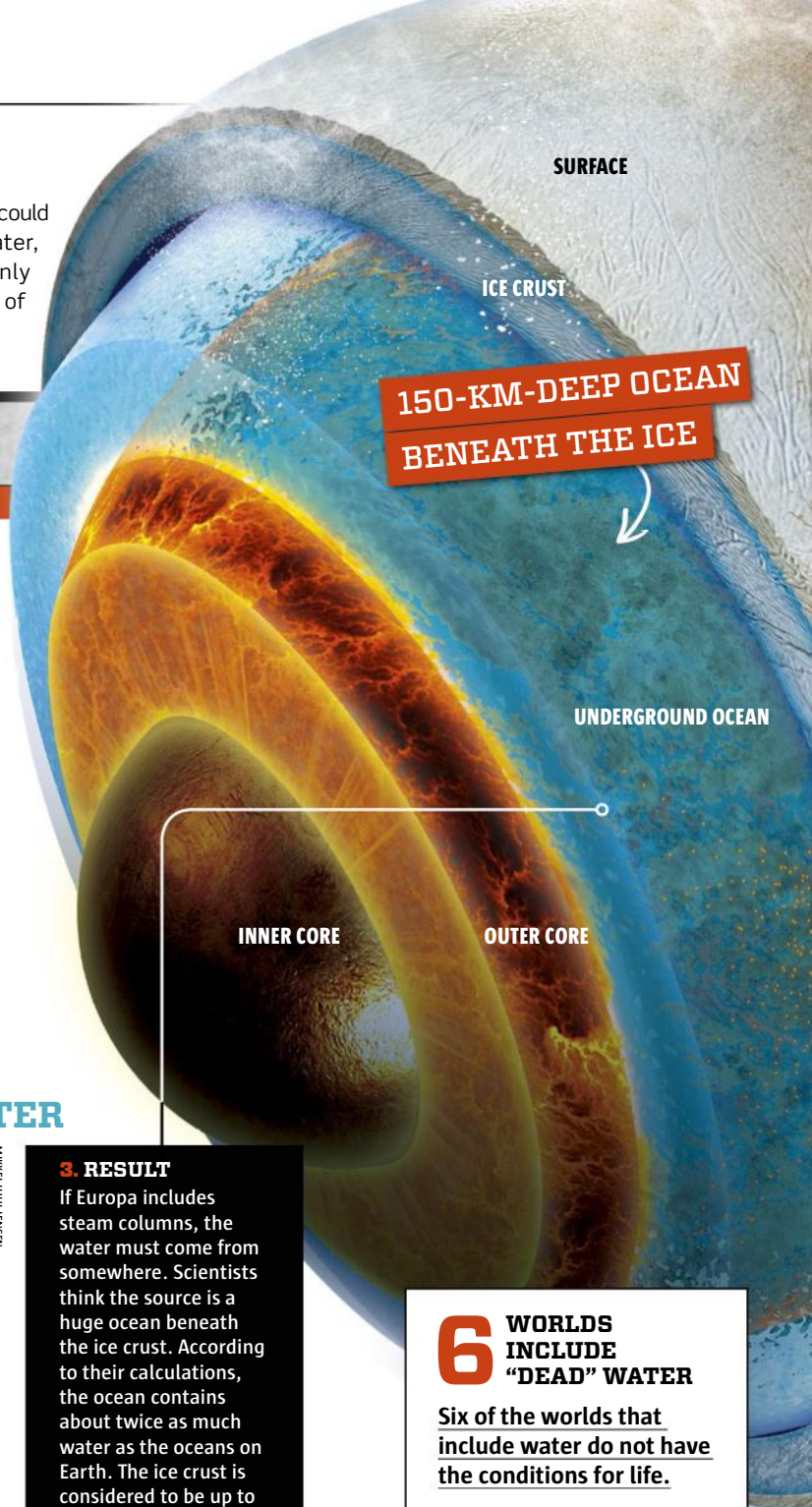
For 15 months, the Hubble telescope has taken ultraviolet images of Europa, as it passed in front of Jupiter, using the Imaging Spectrograph instrument.

### 2. DISCOVERY

In three of the ultraviolet images, scientists saw something that they think must be steam columns. Some of the steam turns into ice and falls back onto the surface.

### 3. RESULT

If Europa includes steam columns, the water must come from somewhere. Scientists think the source is a huge ocean beneath the ice crust. According to their calculations, the ocean contains about twice as much water as the oceans on Earth. The ice crust is considered to be up to 25 km thick, whereas the ocean is up to 150 km deep.



## 6 WORLDS INCLUDE "DEAD" WATER

Six of the worlds that include water do not have the conditions for life.

**CERES** 25 % of the dwarf planet consists of water ice.

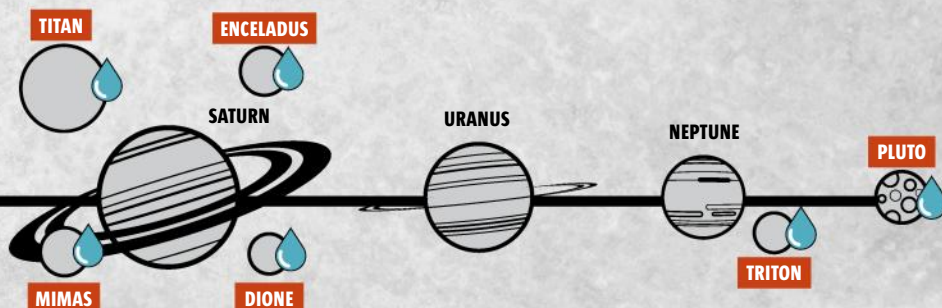
**CALLISTO** The moon hides a 10-km-deep ocean under the ice.

**TITAN** The underground ocean is as salty as the Dead Sea.

**MIMAS** An ocean exists about 25 km beneath the surface.

**DIONE** The moon may hide a huge ocean 100 km under the ice.

**TRITON** Cracks in the ice indicate an ocean under the surface.





► In the autumn of 2015, NASA proclaimed that scientists had found evidence of salt water flowing down the sides of Martian craters during the summer. The evidence were long, dark lines appearing in the craters in the summer and disappearing in the winter. However, subsequent studies made by the Mars Odyssey probe have shown that the lines hold a maximum of 3 % of water – the same as a desert on Earth. At worst, the lines do not contain any liquid water at all, rather they consist of salts that attract a small quantity of water molecules from the atmosphere.

If so, astronomers need to find out why the lines come and go. A rover such as Curiosity, which is presently roaming Mars, could help, so NASA is considering to send the robot to one of the areas to take a soil sample.

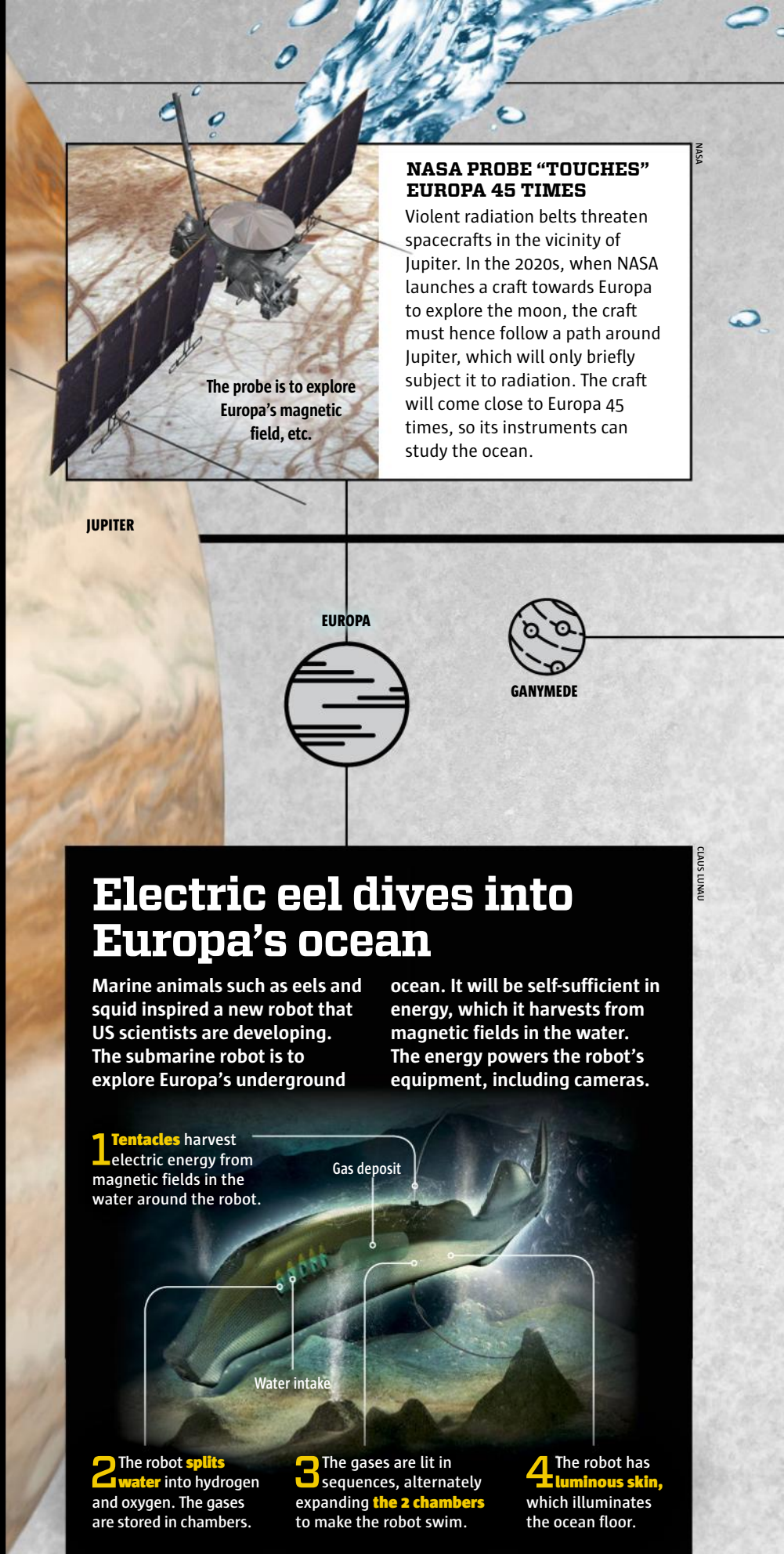
### PLUTO SURPRISES ASTRONOMERS

In 2016, yet another surprise came up in the search for liquid water. The dwarf planet of Pluto, which is located on the other side of the Solar System's most remote planet, Neptune, may include an ocean. The water is freezing, but it may still be liquid.

New images of Pluto taken by the New Horizons spacecraft in 2015 show external, tectonic features revealing that the world has expanded. The expansion could be due to an ocean that is gradually freezing. Based on the new observations, scientists from the US Brown University have been able to update the model of temperature developments on Pluto. If the ocean had already frozen into water ice, it would relatively quickly turn into a special type of densely packed ice due to the high pressure and the low temperatures in Pluto's interior. That would cause a contraction of the dwarf planet, of which scientists see no signs on the surface. So, the team believes that the water beneath the ice crust may still be liquid.

Space agencies' search for liquid water does not stop with Pluto. In the 2020s, both NASA and the European Space Agency, ESA, plan to send new craft to Jupiter to take a closer look at the ice moons.

In the long run, cautious fly-bys will, however, not be enough. Instead, craft must land on the surfaces of the worlds. This requires a lot from the measuring equipment that is to function in radiation which is forceful enough to short out the costly gear. If the underground oceans are to be seriously studied, engineers must figure out how to send an unmanned submarine into them, so scientists can find out if the liquid water includes living creatures. **SC**



### NASA PROBE "TOUCHES" EUROPA 45 TIMES

Violent radiation belts threaten spacecrafts in the vicinity of Jupiter. In the 2020s, when NASA launches a craft towards Europa to explore the moon, the craft must hence follow a path around Jupiter, which will only briefly subject it to radiation. The craft will come close to Europa 45 times, so its instruments can study the ocean.

The probe is to explore Europa's magnetic field, etc.

JUPITER

EUROPA

GANYMEDE

## Electric eel dives into Europa's ocean

Marine animals such as eels and squid inspired a new robot that US scientists are developing. The submarine robot is to explore Europa's underground

ocean. It will be self-sufficient in energy, which it harvests from magnetic fields in the water. The energy powers the robot's equipment, including cameras.

**1** Tentacles harvest electric energy from magnetic fields in the water around the robot.

Gas deposit

Water intake

**2** The robot splits water into hydrogen and oxygen. The gases are stored in chambers.

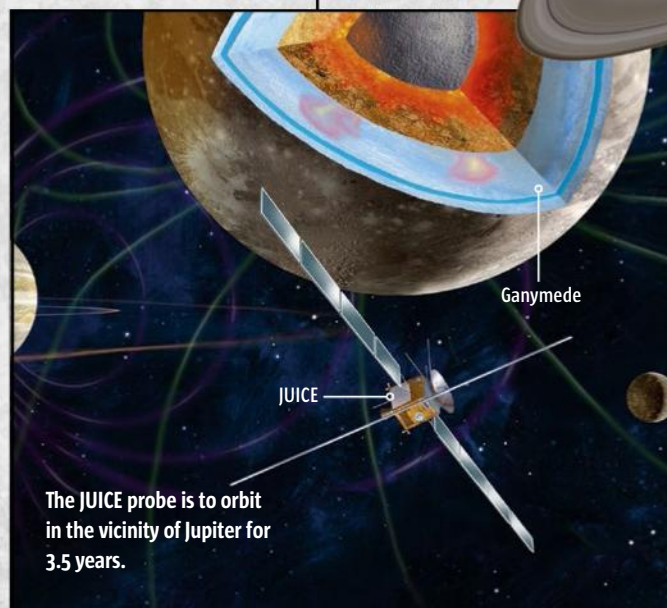
**3** The gases are lit in sequences, alternately expanding the 2 chambers to make the robot swim.

**4** The robot has luminous skin, which illuminates the ocean floor.



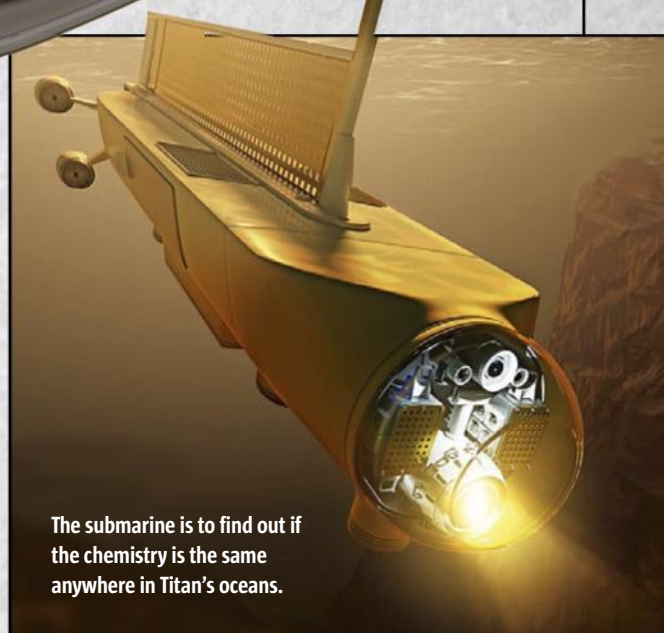
# Water hunters heading for Jupiter and Saturn

In the 2020s, spacecraft will head for the two giants of the Solar System, where they are to fly by selected moons and collect new evidence of liquid water. In the future, the aims are even higher, including diving into the underground oceans to find any evidence of life.



## PROBE VISITS THREE MOONS

When the European JUICE (Jupiter Icy Moons Explorer) probe leaves Earth in 2022, it will head for the Ganymede, Callisto, and Europa moons, which are all orbiting Jupiter. The three moons could very well have the right conditions for both liquid water and life. During the 11 year mission, the spacecraft will orbit Ganymede, exploring whether the moon is hiding large quantities of water beneath the hostile ice crust.



## SUBMARINE TO EXPLORE TITAN'S OCEANS

Saturn's largest moon, Titan, has liquid oceans on the surface, but the oceans consist of liquid methane. NASA will explore the oceans in great detail by means of an autonomous submarine, Titan Submarine, that is to sail along the coasts and dive into the northern ocean of Kraken Mare. According to plan, the submarine is to shed light on the about 1,000-km-large and 300-m-deep ocean, including chemistry, floor, and currents.



# THE MAMMALIAN VICTORY

65 million years ago, when a huge meteor wiped out the dinosaurs, leaving life on Earth in a state of chaos, the race to become Earth's new ruler began. Recent research demonstrates that our ancestors were the first to act.

SHUTTERSTOCK





MAMMALS ROSE  
FROM THE ASHES  
TO CONQUER  
THE WORLD.





# Mammals beat reptiles and birds

In the ashes of huge dinosaurs, three groups of animals began the struggle to conquer Earth.

**A**fter the meteor strike, the dinosaurs tried to reconquer the planet. The only surviving dinosaurs, birds, grew to giant sizes with strong legs and powerful jaws, and some were probably at the top of the food chain. Their scaly relatives, crocodiles, also made an attempt to become dominant. Some evolved into giants, and others became fast-running terrestrial predators that feasted on the ancestors of

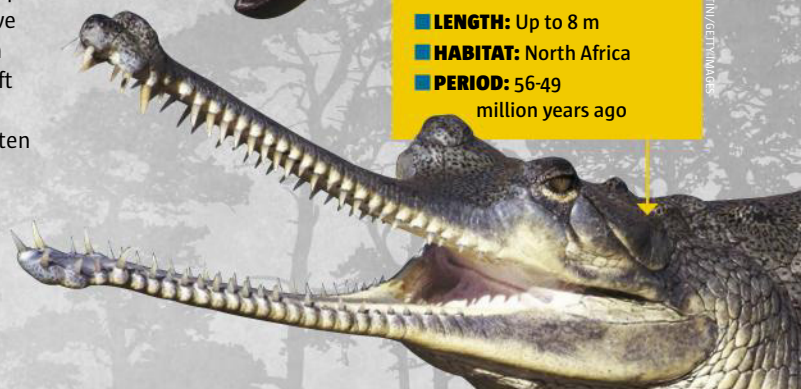
mammals. Even snakes joined the battle, producing the 14-m-long Titanoboa constrictor. Each group of animals displayed an explosive evolutionary development in an effort to take over the throne left by the large dinosaurs. Nevertheless, they were all beaten by a group of small, rat-like insectivores, which very quickly developed into the wealth of different life forms that dominate the world today.



## Phosphatosaurus:

- **LENGTH:** Up to 8 m
- **HABITAT:** North Africa
- **PERIOD:** 56-49 million years ago

DE AGOSTINI/GETTY IMAGES



**W**hen a 34 billion tonne rock slammed into a shallow ocean near what is now Mexico at a speed of 30 km/s, it changed Earth's history. The collision released energy corresponding to 1+ billion nuclear bombs. Burning rocks were flung through the atmosphere, causing wildfires throughout the planet, and huge tsunamis washed up on the shores. For decades, a worldwide cloud of dust blocked out the sunlight, temperatures plummeted, and plants died. After 160 million years of world domination, the large dinosaurs had been wiped out along with 75 % of all life. In the ruins of the lost world, a group of small, lucky survivors, including birds, crocodiles, snakes, and mammals, remained. The planet was waiting to be conquered, and a brutal race began to reach the top of the food chain and become Earth's new rulers. Today – 65 million years later – scientists finally have a clear impression of the important moments of the struggle.

## GREENHOUSE GASES HEALED EARTH

The giant meteor strike marked the end of the Cretaceous and the beginning of the next period in Earth's history, Paleogene. After decades of darkness and cold, the dust settled, and slow liberation of greenhouse gases from Earth's interior made sure that the planet became

warmer again. Temperatures ended almost 15 degrees above the present average, and the warm climate spread from pole to pole. Lush rainforests and hardwood forests covered most of the land, and the poles were clear of ice. In many ways, Earth had returned to its heyday, but one vital element was gone, leaving a gaping wound in the global eco-system. The huge dinosaurs, that had dominated the planet in the shape of herbivores weighing several tonnes and awesome predators, had died out. Only one single group of dinosaurs, the birds, had survived. Other groups of animals were also in a bad shape, and only about 10 % of the mammals had made it through the disaster.

## MANY NEW SPECIES

The evolutionary race in early Paleogene has been a highly debated subject among scientists for years. One group, geneticists, use analysis of modern animals' genes to calculate, when individual groups of animals evolved. The scientists take a look at the number of differences in the genes of dogs and elephants, etc. As they know how quickly the differences occur, they can calculate, when the two species' common ancestor must have lived. Such studies have shown that the ancestors of modern



## Titanoboa:

- **LENGTH:** Up to 14 m
- **HABITAT:** Colombia
- **PERIOD:** 60-58 million years ago

ROMAN UCHTEL





#### Gastornis:

- **HEIGHT:** Up to 2 m
- **HABITAT:** Europe, North America, China
- **PERIOD:** 60-41 million years ago

ADP/70

## Fantastic Beasts - We Found 'Em!

Apart from some of the animals that we know today, when the mammals rose, some of the oddest creatures in the history of Earth appeared.

### Hooved carnivores?

The world's biggest carnivorous terrestrial mammal, *Andrewsarchus*, was neither a tiger nor a bear. It was a cloven-hooved creature like pigs and cows. A human being would have reached its shoulders, and the huge predator weighed almost 1000kg. *Andrewsarchus* ruled Mongolia 45 million years ago, consuming anything within reach (even bears).



### Jumpy longnose!

The mammals only rarely moved about on two legs, but the small *Leptictidium* made an attempt. According to scientists, it may have been able to use its hind legs to both jump and run. Apart from a pair of long legs, the *Leptictidium* also had a small trunk that it may have used to poke about for insects and worms in the ground.



### Six-horned beast

Scientists have long discussed where the *Uintatherium* belongs on the evolutionary tree of mammals. The odd, 2000kg animal has no less than six horns on its head and a set of impressive canine teeth. Horns and teeth were probably used to attract mates or defend itself against enemies. Today, scientists believe that the *Uintatherium* is related to horses and rhinos.



Many of the mammals that evolved after the meteor strike have no modern descendants.

mammals originated at an even pace throughout the Cretaceous (150-65 million years ago), and their evolution only really began to pick up pace more than 10 million years after the demise of the large dinosaurs.

The problem is that the method is very inaccurate, when scientists are to calculate so far back in time. That is the reason why some scientists rely on fossils instead, and fossilized skeletons tell a very different story indeed.

In the most detailed study so far of fossils from the period around the meteor strike, scientists from University College London have provided us with an extremely clear impression of the evolution of early mammals.

The scientists studied several different aspects of the evolution of early mammals. First, they looked at the number of species over time and found that a wealth of new mammal species evolved in early Paleogene. Subsequently, they analysed the variation between species concerning shapes and sizes, discovering that the mammals obtained a huge variety of body types in no time. The results show that the mammals did not hesitate for a single moment. Their evolution "exploded" at the ►



# Flexible body was ready for success

Seven characteristics provided mammals with the perfect starting point for taking over from the dinosaurs. Even today, the features ensure mammal world dominance.

1

## Large brain finds new solutions

Mammal brains include more cerebral cortex and are hence much bigger than the brains of most other same-size animals.

7

## Teeth ensure a varied diet

Different tooth shapes have allowed mammals to feed on anything from turtles to algae, benefitting to the maximum.

6

## Subdivided heart sends oxygen to body

An extra cardiac wall ensures that oxygen-rich blood from the lungs is not diluted before reaching oxygen-starving body cells.

5

## Milk provides vital nourishment

Mammal milk contains fat, carbohydrates, and vitamins, i.e. everything the offspring needs in order to grow.

With a weight of 22 tonnes, the *Palaeoloxodon* was the size of some of the biggest dinos.

ROMAN UCHYTEL

► moment that the large dinosaurs disappeared from Earth's surface.

## BIZARRE MAMMALS CONQUERED EARTH

Over a period of a few million years, almost all the groups of mammals that we know today evolved – along with a long series of odd groups that have long disappeared again. The mammals were the fastest starters, and though they faced steep competition from awesome, 170 kg birds and huge, 14-m-long snakes, they always came up with a powerful response. The tapir-like *Barylambda* weighed 650 kg and dominated the world of herbivores,

while the *Arctocyon*, a predator the size of a bear, was at the top of the food chain.

In the trees, you would encounter the *Ocepeia*: a small, mysterious animal that may have been the ancestor of hyraxes, sea cows, and heavy elephants. In the oceans, you could experience bizarre, cloven-hooved animals that evolved into the rulers of the oceans, the whales. Mouse-like animals developed membranes between their long fingers and began to fly awkwardly from tree to tree, until they fine tuned their capacity, turning into modern bats. Bears, dogs, and cats, which

now include the largest terrestrial predators, can also date their common ancestor back to this era in the shape of the *Dormaalocyon*, which weighed about 1 kg. And in the trees, you would find the *Purgatorius*: a small, rat-like creature, whose descendants were monkeys – and humans.

## FUR ENSURED EXTRA ENERGY

The overwhelming success of mammals from early Paleogene was the result of an extremely adjustable body. One of their most unique features was the ability to produce milk for their young. The whitish liquid



2

### Extra ear bones help mammals navigate

Three bones in the ear provide mammals with remarkable hearing, allowing more animals to move about in the dark.

3

### Fur keeps animals warm anywhere

Furry insulation allows mammals to keep up body temperatures of 40 degrees even at temperatures of minus 50 degrees.

4

### Flexible limbs = more freedom

Four adaptable limbs allow mammals to move bodies that weigh several tonnes about the land, the oceans, and the air.

probably originated among reptile-like mammal ancestors, which used it to keep their eggs moist in dry surroundings. When they subsequently began to make the eggs develop inside the womb and gave birth to living offspring, the milk obtained another function. Its contents of nutrients was optimised to give the young the best start in life, and the liquid allowed the mother to transfer her immune bodies, so the offspring was protected against diseases. The parents were no longer forced to collect food for the young, i.e. they were less dependent on the constant availability of energy-rich food.

## Young mammals get a good start in life

During the era of the dinosaurs, mammals split up into three groups with different strategies for preparing their young for a hard life.



### ODD MAMMALS LAY EGGS

Monotremes, including the platypus and the echidna, are the only modern mammals that lay eggs. Rather than sucking a teat, the baby laps milk that oozes out of the mother's skin.



### BABIES CLIMB TO GET MILK

Kangaroos and other marsupials give birth to babies that are able to climb to their mothers' pouches, where they are breastfed, until they are old enough to leave the pouch.



### BABIES NOURISHED VIA BLOOD

Humans are placental mammals, who are nourished via their mothers' placentas in the embryonic stage. The placenta transfers nutrients and oxygen from the mother's blood.

The fur was also very important for early mammals, helping them keep warm, when temperatures fell, and keep out heat, when it was hot. The body temperature was determined by the high metabolism that ensured constant body temperatures. The constant temperature provided optimum conditions for body cells and allowed the animals to keep up high energy levels throughout the day. Unlike cold-blooded reptiles, which depend on sunlight, mammals could adjust to cold regions or be active during the night. The extra energy also made it possible to forage across larger areas and hunt prey more efficiently.

The high activity level was only possible, because the mammals had developed a more sophisticated heart. Whereas a reptile heart only boasts three chambers, mammals have developed a heart with four chambers. The extra subdivision means that oxygen-rich blood from the lungs is not mixed with oxygen-poor blood from the body, before it is pumped into the blood vessels, so the cells of the body constantly receive large quantities of oxygen that can power the animals' high metabolism and keep them active.

### SENSES MADE THE BRAIN GROW

An impressive set of teeth provided mammals with yet another advantage in the evolutionary race. Unlike most other animal groups, every single mammal has a number

of different types of teeth in its mouth, and the tooth types vary from species to species. Humans have front teeth, canine teeth, and molars that each have their own functions. Like in many other mammals, our teeth allow us to eat a broad range of different food and pulverize it, so we can consume the nutrients faster and more efficiently.

The ability to adjust to almost any habitat and any type of food was boosted by mammals' flexible limbs. Whereas bird hands had been reduced into a set of feathered fingers, mammals could use all four limbs freely and were able to use their front legs to crawl, dig, handle food and tools, and support their heavy bodies. The freedom allowed mammals to take better advantage of their surroundings and resources, growing to giant sizes.

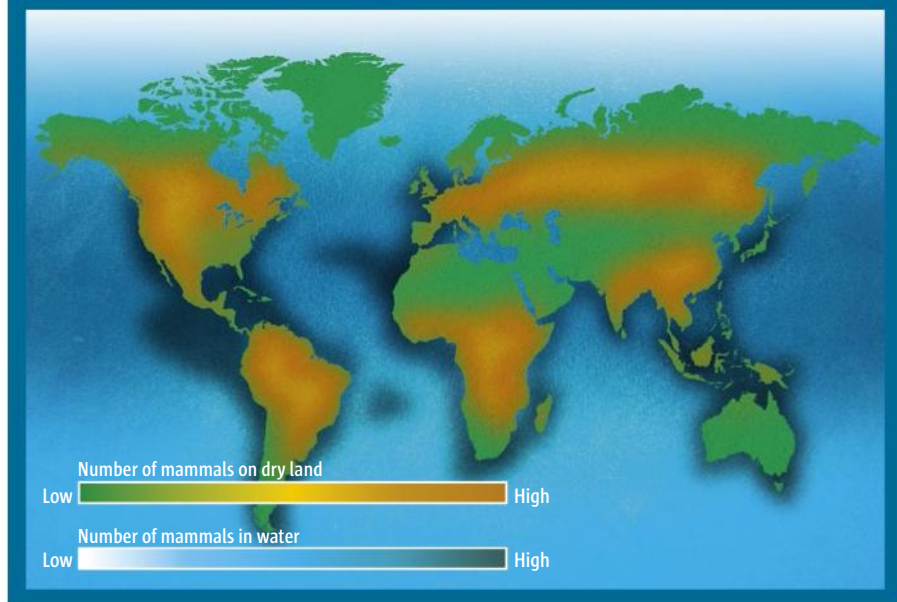
However, the key to mammals' explosive conquest of the planet is primarily found inside their heads. The first mammals developed a set of new bones in their ears known as the hammer and the anvil. Together with a third bone, the stirrup, which also exists in reptiles and birds, the new bones allowed mammals to hear more high-pitched sounds than other animals. Moreover, ancient fossils show signs of improved olfactory and sensory senses – boosted by the development of fur that allowed sensitive whiskers. A thorough study of the skulls of mammal ancestors has revealed the effect ►

ARDEA/ALL OVER & JOHN CANCALOS/NATUREPI & SPL



## Mammals have conquered the entire planet

Burning hot deserts, freezing cold polar ice, and oceans with depths of several kilometres have not stopped mammals from dominating Earth.



► of the improved senses. To handle sensory impressions, mammals developed larger brains, and the extra brain capacity was quickly used. From being confined to interpret sensory impressions, the new brain centres were increasingly used for problem solving. In humans, the vast majority of the cerebral cortex has developed from these new innovative features. Intelligence is one of the most vital factors, when animals are to adjust to new habitats, and the mammals of Paleogene were more than smart enough to conquer the entire planet.

### COLD MEANT NEW OPPORTUNITIES

Once mammals had become the dominant species, they never gave up the position. About 20 million years after the meteor strike, the climate started to change, benefitting mammals even more. Continental drift tore Antarctica and Australia apart, causing new ocean currents around Antarctica, which stimulated slow cooling of Earth.


As temperatures fell, the ice caps of the poles grew. The water was tied up, ocean water levels fell, and new land bridges were produced between territories that used to be isolated. Moreover, India collided with Asia, Africa hit Asia, and Europe and North America got in contact with South America, allowing mammals to spread more easily.

The cold climate also changed the make-up of the ecosystems, which were no longer

dominated by dense forests. Earth now included deserts, tundra, and vast grass plains, and the new environments paved the way for even more variation among mammals and triggered the development of huge herbivores and fast predators.

### DIVERSITY ENSURES DOMINANCE

The mammals won the race both on land and in the oceans. The success is not about the number of species, as both birds and reptiles beat mammals in this respect. Instead, the global dominance is based on a unique diversity of body shapes, life styles, habitats, and sizes. Mammals come with wings, fins, and legs. They live in mountains and in the ground. They include some of the smallest terrestrial vertebrates and whales: the largest animals that ever existed on the planet.

The considerable diversity was possible because of a meteor strike that changed Earth's destiny in a matter of a few seconds. Had the meteor not struck, or had mammals been slow to begin their evolution, the world might have been a different place today. But a combination of random factors meant that our ancestors became the winners. 

6,000 M

**HIGHEST FLIGHT**

### Mexican bulldog bats

Millions of Mexican bulldog bats collect in Texas every year to chase insects at an altitude of 3,300 metres.

3,000 M



**TINIEST**

### Etruscan shrew

Adult Etruscan shrews on average weigh 1.8 g, and without the tail, their bodies do not measure any more than 4cm.



3,000 M



# Mammals push the boundaries of life

No other animal group in the history of Earth has been able to go to extremes at any end of the scale like mammals have.

## Yac

Domestic yacs can live at altitudes of 6+ km, where most other animals collapse due to lack of oxygen.

**HIGHEST CLIMB**

**LARGEST TERRESTRIAL ANIMAL**

## African elephant

A male elephant can weigh up to 11 t and is hence almost 10 times heavier than the largest modern crocodiles.

**DEEPEST DIVE**

## Beaked whale

Cuvier's beaked whale can hold its breath for 2+ hours to reach depths of 3 km.

**LARGEST**

## Blue whale

With its up to 200 t, the blue whale is not only the largest modern animal, it is the largest that ever lived.



# THE END OF RUSH HOUR?

The traffic of the world is concentrated in the big cities. The worst traffic jam in history lasted for 12 days.

DONG WENJIE/GETTY IMAGES



Endless taxi lines, crammed subways, and dysfunctional timetables. Transport in the world's densely populated cities has become a nightmare. Luckily, engineers' solutions are just around the corner.

## One day, you can ...

### ■ Book a bus module via an app

NEXT



### ■ Zigzag through traffic in a driverless motor bike

ASHISH THULKAR



### ■ Fly above traffic in a drone taxi

EHANG



### ■ Be taken to your doorstep in your own train compartment

SKYTRAN





Over the speakers, it is announced that the train will be even more delayed. The crammed commuters sigh. On the roads, the long lines of cars are not moving. Honking and toxic exhaust gases fill the morning air in the city.

In the world's most heavily trafficked cities, the average delay during the busiest

hours of the evening is now 100+ %, i.e. the ride from work, that would normally take an hour without jams, takes two hours.

At the same time, the traffic volumes of the world are rising, and they are constantly increasing in big cities.

People's wandering attention, slow response time, and tendency to overreact are

often the factors causing traffic jams on the roads, and so, engineers are working on leaving the control of cars completely to reliable technology and intelligent software.

### COMPUTERS ARE NEW IN TRAFFIC

Only 13 years ago, computer technology was still light years from being able to control a

London by bus: The average speed of the worst route is 8 km/h



SHUTTERSTOCK

### SOLUTION:

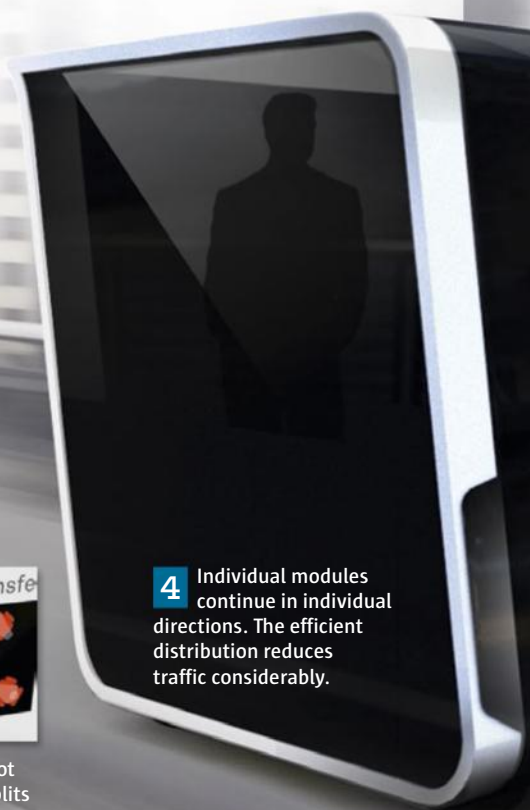
## Small “bus modules” come when you call

The Next Future Transportation company has come up with a new city bus concept. Now, buses have fixed routes and schedules, but the Next buses will be made up of small, driverless modules that work out the route according to passengers'

requirements. One module picks up passengers, who have booked a ride via an app. En route, the module can hook up with other modules on the same route, resulting in a “regular” bus, where passengers going the same way collect in the same module.

It is also possible to call service modules with cafés or toilets, which hook up with the “bus”. According to the company, the system can reduce traffic by up to 78 % as compared to other driverless solutions, which are not made up of modules.

A Next module can seat six, and another four passengers can stand up.



### MODULE BUSES REDUCE TRAFFIC

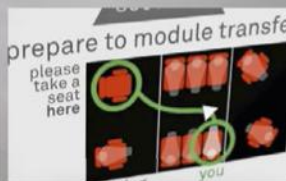


**1** The bus module is booked via an app. Shortly after, a driverless module arrives at your location.

NEXT



**2** When modules share the same route, they hook up on the streets. Doors at both ends allow passengers to move from one module to another.



**3** When the routes are not the same, the “bus” splits up. The app tells passengers heading in the same direction which module to choose.

**4** Individual modules continue in individual directions. The efficient distribution reduces traffic considerably.



car as well as a human being. In 2004, when the US armed forces' research agency, DARPA, held its first driverless car race, the best car only managed to complete 12 km of the 240 km route, before getting stuck on a hill. The result was bad news for the proponents of driverless cars. If they could not even navigate safely about a closed track, they would never stand a chance in much more complex city traffic.

But already about 10 years later, driverless cars had gone through a transformation. In 2015, electric car maker Tesla introduced an automatic pilot system that was able to change lanes on a motorway, which had been identified as a major challenge to driverless cars. The next year, Google's driverless car passed one of city traffic's major tests: cyclists. The cars were now able to recognise signals such as an arm indicating a turn by a cyclist and keep a proper distance to turning cyclists.

The improvements have been vital for restoring faith in computer-controlled cars. In several countries, companies have now been allowed to test their new technologies on open roads among other motorists. However, a human driver must be ready to take over, if the car is about to get in trouble. ►

## Beijing by car: The world's worst traffic jam lasted 12 days



SHUTTERSTOCK

### SOLUTION:

## Zigzag through traffic in a driverless motor bike

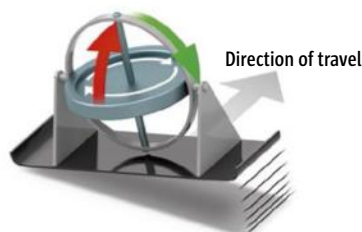
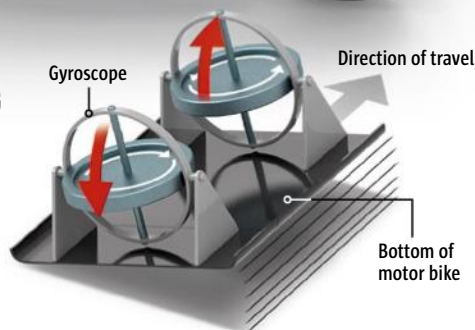
The conceptual Cyclotron motor bike is to take advantage of two-wheeled vehicles' ability to keep on going, although cars are not moving forward. Cyclotron will be driverless and seat two passengers. Among the motor bike's most important elements are two gyroscopes located at the bottom of the vehicle. Each gyroscope is made up of a horizontal metal disc that

rotates its own axis 10,000 times per minute. When a disc rotates, it generates force perpendicularly to the disc. By tilting the discs inside the gyroscopes, the force can be controlled and used to stabilise the motor bike. The two rotating discs enable Cyclotron to remain in an upright position, even when waiting at a red light or being involved in a collision.

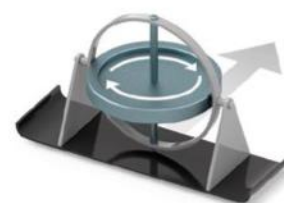


### GYROSCOPE PREVENTS TILTING

**1** The two gyroscopes each consist of a rotating disc, that rotates in the opposite direction of the other. As the bike slants, the discs tilt in opposite directions.



**2** When a rotating disc is tilted, it will try to get back to its original position. The disc produces a force perpendicularly to the tilt.



**3** So, the force of the gyroscope counteracts the tilt towards the left, putting the motor bike straight again. It is the same principle as that of a spinning top.



Tokyo by subway:  
Six people per  
square metre

RAFAEL MACIA/GETTY IMAGES



**Top speed:**  
100 km/t.

**Battery:**  
The present prototype can remain in the air for a total of 23 minutes. A battery recharge takes two-four hours.

**Propellers:**  
Ehang 184 is equipped with eight propellers located in pairs in an X pattern. This provides the drone with the advantage of the force of eight propellers in the same compact shape as four. Moreover, the drone can still land, if one of more propellers were to fail.

**Motor:**  
The eight electric motors have a combined output of 106 kW or the equivalent of 142 hp. That is about the same as a small car.

**Weight:**  
The drone weighs 200 kg and can carry a load of up to 100 kg.

#### SOLUTION:

## Pilotless drone taxi ready for takeoff

In the future, traffic jams could be a thing of the past. In early 2016, the Chinese company Ehang introduced the pilotless Ehang 184 drone. Seating one single passenger, the drone is one of the world's first pilotless transports. The only thing the passenger needs to do is to enter his destination. Subsequently, the computer takes care of navigation and communication with other aircraft nearby. However, the

drone is still under development, as the present version can only remain in the air for about 23 minutes on a fully-charged battery. According to Ehang, the pilotless drones will be monitored from small command centres manned by trained pilots, who are ready to take control in the event of problems. The company has been allowed to carry out test flights in Nevada, USA.

► Safety is one of the most important reasons for introducing driverless cars. Every year, 1.25 million people lose their lives as a result of traffic accidents throughout the world. It is estimated that at least 90 % of the accidents are due to errors made by humans. If the traffic only consisted of driverless cars, the percentage could fall to almost nothing.

If all traffic decisions were left to computers, the existing space on the roads would also be used much more efficiently. The driverless cars would constantly exchange information. Based on data from Internet-linked traffic lights and other driverless vehicles, the cars would know everything about city traffic and would consequently be able to anticipate future traffic jams, choosing an alternative route.


But no matter how intelligently the cars would spread, driverless vehicles will never be the most space efficient solution on routes with heavy traffic. According to transport expert Yonah Freemark, driverless cars are no longer sufficient on city stretches, where more than 5,000 people per hour move in any given direction. Compared to larger vehicles such as buses, cars take up too many square metres per passenger.

#### MASS TRANSPORT MUST BE EFFICIENT

The transport systems of the future will hence also have to involve mass transport in the shape of buses and trains, and these modes of transport include one paramount challenge – the problem of the last mile.

No matter how fast buses and trains become, it will not change the fact that commuters must move to and from the closest station, meaning that walking-impaired people or passengers carrying heavy luggage will very often choose to go to the station by car.

Consequently, the Next Future Transport company is developing small, driverless transport modules that pick up individual passengers at their starting points and drop them off at their end destinations. En route, the modules combine into long carriages, which take up about the same road space as buses, but at the same time, the individual modules have the same flexibility as cars.

At this point in time, there is every indication that within a few years, traffic will be controlled by computers. The Finnish capital of Helsinki aims to have nothing but driverless traffic by 2050, and according to experts, the car as we know it will be a thing of the past in 2070, when driverless units, be it cars, buses, or modules, will have taken over all transportation. 

EHANG



# New York City by taxi: **One in three passengers wait 20+ minutes**

## **SOLUTION:**

## **Take the train to your doorstep**

In many big cities, the stations of the local railway network are often far away from passengers' destinations. Sky Tran is a system with small two-person compartments moving along an elevated track 6 m above the ground. In each car's suspension, you will find a series of powerful magnets that are pushed forward by electricity in the track. Moreover, a number of coils are embedded along the entire length of the track. As

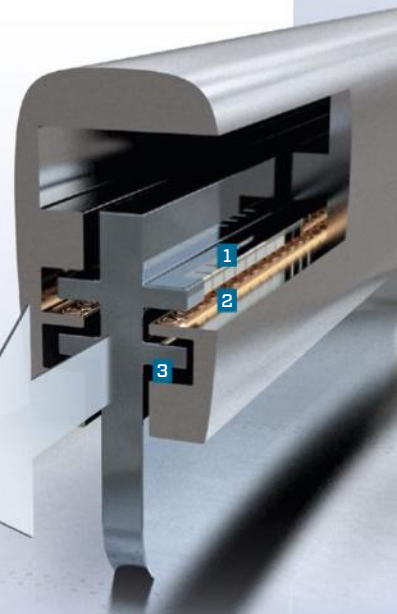
the powerful suspension magnets move, they produce a reverse magnetic field in the track coils, making the car float. This reduces friction and makes skyTran more energy-efficient. The elevated tracks take up much less space than ordinary ones, and hence, it is cheaper to build more tracks and stations, so passengers can be carried all the way to their destinations. According to plan, the first skyTran will be built in Tel Aviv, Israel, within the next few years.

## **MOTION LIFTS THE TRAIN**

- 1** The compartment hangs beneath the track, attached with a rail including **powerful magnets**.
- 2** Along the track, you will find **wires** joined in loops.
- 3** The magnetic field from the permanent magnet induces a current and so a magnetic field in individual track wires. **The induced magnetic field** repels the permanent one, making the compartment float.
- 4** **The compartment** moves along the track without friction. At speeds of 20+ km/h, it will remain floating.



SHUTTERSTOCK



CLAUS LUNAU

**Elevated tracks make it easier and cheaper to build widely ramified local railway networks in cities.**

SKYTRAN





## DEEP SEA SECRETS

We have sent more people into space than to ocean depths of 4+ km. The deep sea is Earth's least explored environment and remains a great mystery to scientists. It includes thousands of undiscovered animal species, the answers to how Earth formed, and threats to all life on Earth.

# Unknown species lurk in the abyss

A small, purple ghost octopus is only the most recent of a series of newly discovered deep sea species. Biologists suspect that we have only met one third of the inhabitants of the deep sea. Every time scientists go there, they find new extreme creatures.



## MYSTERIOUS CREATURES

In the darkness of the abyss, you will find creatures adapted to an extreme environment with temperatures below 5 °C and thousands of kg of pressure.

The common fangtooth patrols with its mouth open at depths of down to 5,000 metres.

DAVID SHALE/NATUREPL

## CRINOID STIMULATED DEEP SEA EXPLORATION

In 1864, a Norwegian surveying vessel secured a crinoid from a depth of 3,109 m. The crinoid is an echinoderm, which is related to starfish, and the discovery made biologists recognize that the deep sea included life that

was worth taking a closer look at. The discovery of the crinoid inspired the English Challenger expedition, the world's first real deep sea expedition, which took place in 1872-1876, bringing back 4,417 new animal species.

Crinoids can grow on the ocean floor at depths of down to 8 km.



Sperm whale lungs can collapse, allowing the animal to hunt at depths of

**2+ KILOMETRES**

– most of the oxygen required by the sperm whale is stored in its muscles.

**90%**

of all marine life lives in the upper 200 m of the water column.

**8,145 METRES**

is the deepest place, in which fish have been observed.

The largest known giant squid was 10 m long and weighed

**495 KG**

# Deep sea creatures live under extreme conditions

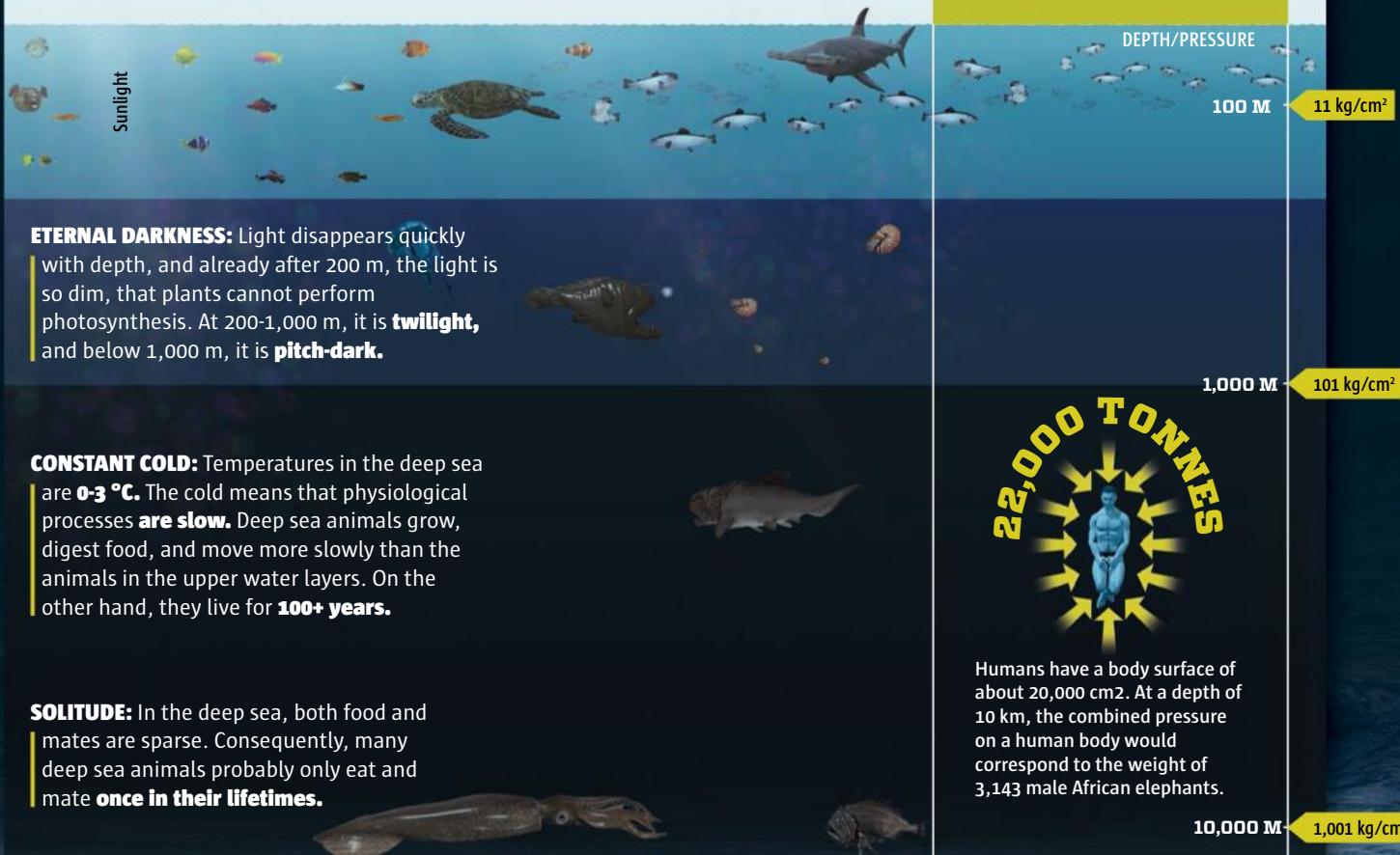
The water is cold, dark, and adds pressure from all sides. To survive in the deep sea, animals must be anti-social and easily satisfied.

In the summer of 2015, two scientists from Hawaii discovered an unknown sea sponge the size of a family car. The sponge was 3.5 m long, 2 m tall, and probably more than 1,000 years old. According to most oceanographers, we only know about one third of the species that exist in the deep sea, and other large,

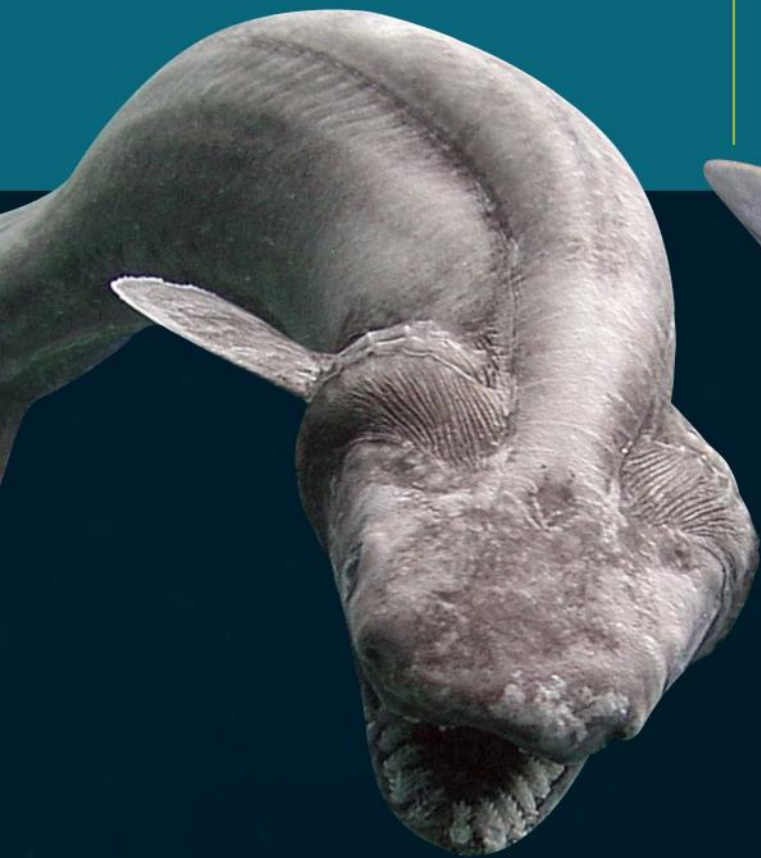
unknown species such as whales, giant squid, and fish may be hiding in the 95 % of the oceans that humans have not yet seen. The deep sea is not an easy place to explore nor live in. The extreme pressure makes up a specific challenge – both to deep sea species and to exploration vessels.

## EXTREME PRESSURE IN THE DEEP SEA

For every 10 m, the pressure increases by 1 kg per cm<sup>2</sup> of body surface. The animals only survive, as they primarily consist of water. Liquids can hardly be compressed.







The frilled shark has the **longest gestation period** of any animal:

**3.5 YEARS**

A **30 CM** DIAMETER  
is characteristic of the **largest eyes of the animal kingdom**.  
They belong to the colossal squid.

The goblin shark can move its jaws forward to a point, in which they almost reach the tip of its snout.

MASA USHIODA/SEAPICS & AWASHIMA MARINE PARK/GETTY IMAGES



## The world's oddest sharks live in Japanese oceanic trench

Living fossils and snouts like sword blades. Deep sea sharks have developed odd appearances.

For unknown reasons, the deep waters around the Japanese islands are the home of sharks that are very different from their peers. A few have been known for quite a while, as they are regularly caught by line fishermen, but several of the sharks were only discovered very recently.

The most well-known example is the goblin shark, which has a large, protruding mouth and a long, pointed snout that seems almost like a

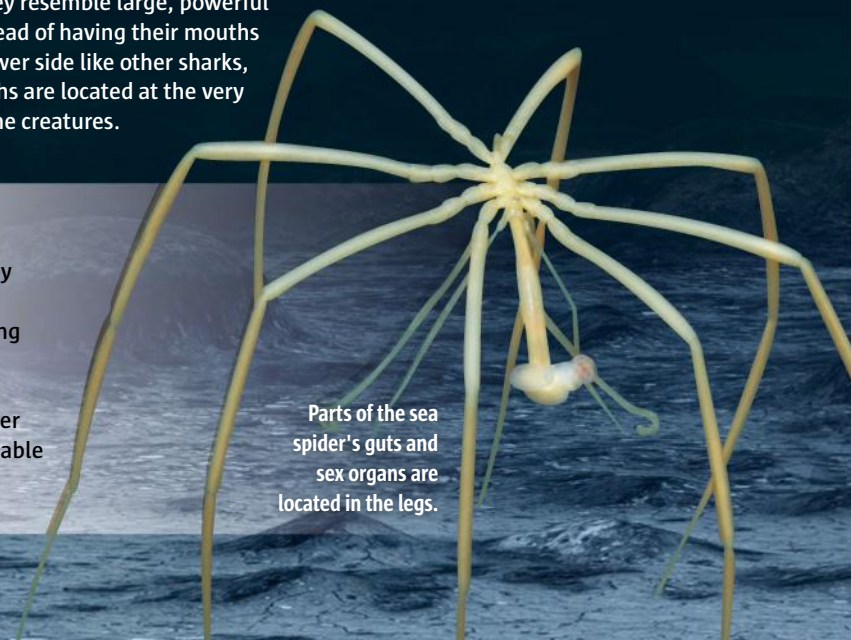
sword among some individuals. The shark has never been studied in its natural habitat, so scientists do not know much about it or the purpose of the sword.

Frilled sharks are just as odd. They are very primitive sharks that look like hundred-million-year-old fossils discovered through-out the world. Frilled sharks are not much like sharks, rather they resemble large, powerful eels. Instead of having their mouths on the lower side like other sharks, the mouths are located at the very front of the creatures.

### Everything is in the legs

Sea spiders can make any arachnophobe sweat. With their long, spaghetti-like legs, they do not look like any other marine animal. The body is almost nonexistent, and most organs are located in the upper joints of the legs.

In spite of the name, they have nothing to do with spiders apart from sucking life out of their prey. Sea spiders feed on small, defenceless prey, as larger animals would easily be able to break their thin legs.



Parts of the sea spider's guts and sex organs are located in the legs.



1857

was the year, in which Danish biologist Japetus Steenstrup was the first to describe the giant squid.

A dead whale, which sinks to the bottom, can feed deep sea scavengers for up

to 100 YRS

The Japanese spider crab is the world's largest arthropod with a leg span of

5.5 METRES

# Octopuses are the deep sea superstars

About every time we film the deep sea floor, new octopus species are captured. The creatures have a special ability to develop new species.

The vampire octopus is 30 cm long and can shoot with luminous ink.



## The gloomy prince of darkness

The vampire octopus is the most well-known deep sea octopus with large, luminous eyes and spiky arms, which make up a mantle along with the sombre, dark brown skin. The octopus does not suck blood from its prey, but it owes its name to its scary appearance.

STEVE DOWNER/ALLOVER PRESS

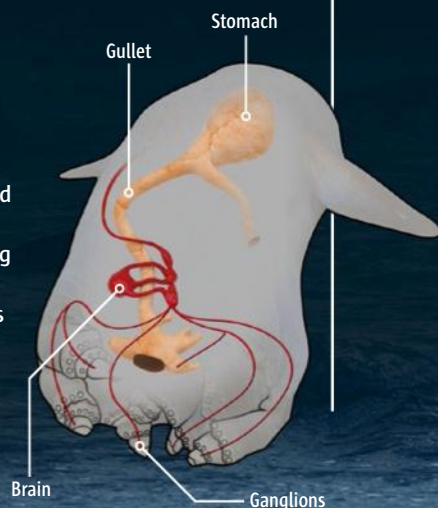


The Dumbo octopus owes its name to its elephant ear-like fins.

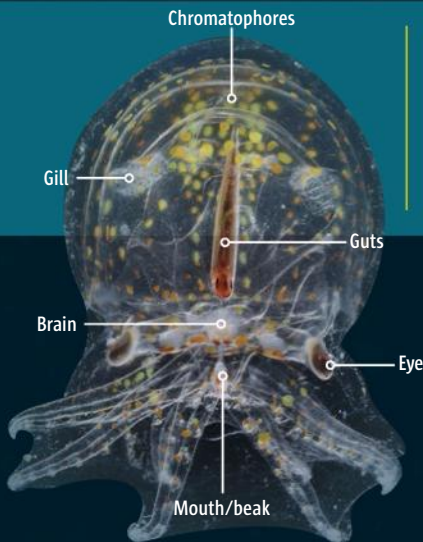
## The brain is in the gullet

Dumbo octopuses are sturdily built with large, dark eyes and short, blunt arms. They almost look like small rubber beach toys and are often observed sitting on the floor or swimming across it in short jumps. Like other deep sea species, the Dumbo octopus has a very special brain and central nervous system design. Part of the brain typically makes up a ring around the throat, from where large nerves pass to individual arms. At the top of each arm, you will find a ganglion or tiny brain that controls the arm's motions.

NOMA







## Clear view of the organs

The glass octopus is a completely transparent species that allows us to see its internal organs. The brain can be dimly made out. All the coloured spots are chromatophores or pigment cells. The spots probably function as camouflage in young animals that live in the light at a closer proximity to the surface. Most octopuses have round eyes, but the eyes of the glass octopus are very compressed and almost rectangular.

SOUJIN ZHANG/NATURE

Including its long **tentacle fingers**, the elbow squid measures **8 METRES**

**99%** of Earth's **habitable areas** is ocean.

Sixgill sharks live **1,850m** **BENEATH THE SURFACE**



The giant isopod is more than 10 times bigger than its peers at the surface.

## In the dark, isopods become giants

Compared to its peers, the deep sea garbage collector aka the giant isopod grows into a giant of several kilos.

One of the oddest phenomena of extreme environments is that the relatives of small creatures become huge, whereas the relatives of large animals become small. One of the most well-known and scary examples is the giant isopod: a scavenger living in deep waters of the Pacific, the Atlantic, and the Indian Oceans. Normally,

isopods live in shallow waters and are common throughout the world. They typically only grow a few cm long and weigh a few grammes. But in the abyss, they have a different appearance. There, they grow 30-40 cm long and may weigh 3+ kg. According to scientists, giant isopods have grown so big, because they have found a niche as deep sea garbage collectors, which clear up all sorts of dead material that sinks down from higher water layers.

D. R. SCHRICHT/SEAPICS

## Mysterious fingers comb the sand

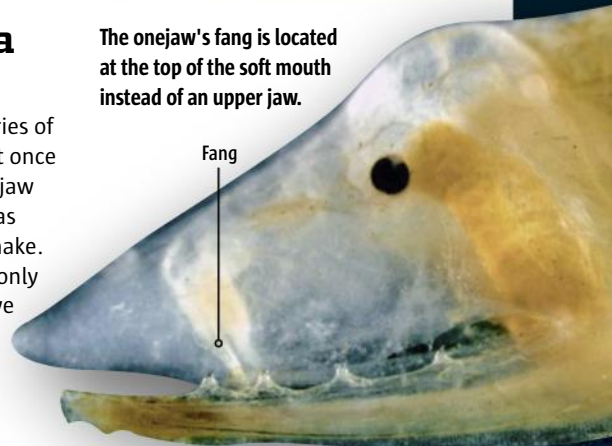
Only very few elbow squid have been observed – captured by underwater cameras near oil rigs, etc. – and they apparently have joints in their arms. The squid flows vertically through the water with the inner half of the arms protruding horizontally to the sides, whereas the outer half investigates the mud of the ocean floor in the shape of thin, trembling fingers.

KEVIN MAZUR

## Onejaws are deep sea venomous snakes

Deep sea fish have developed a long series of different adjustments to make sure that once found, the prey cannot escape. The onejaw solution is unique, as the eel-like fish has developed into a deep sea venomous snake. Though the about 10-cm-long onejaws only have teeth in their lower jaws, they have no problems killing their prey. At the top of the mouth, there is a large fang, which is an outgrowth of the skull and linked with two poison glands.

The onejaw's fang is located at the top of the soft mouth instead of an upper jaw.



W. LEO SMITH

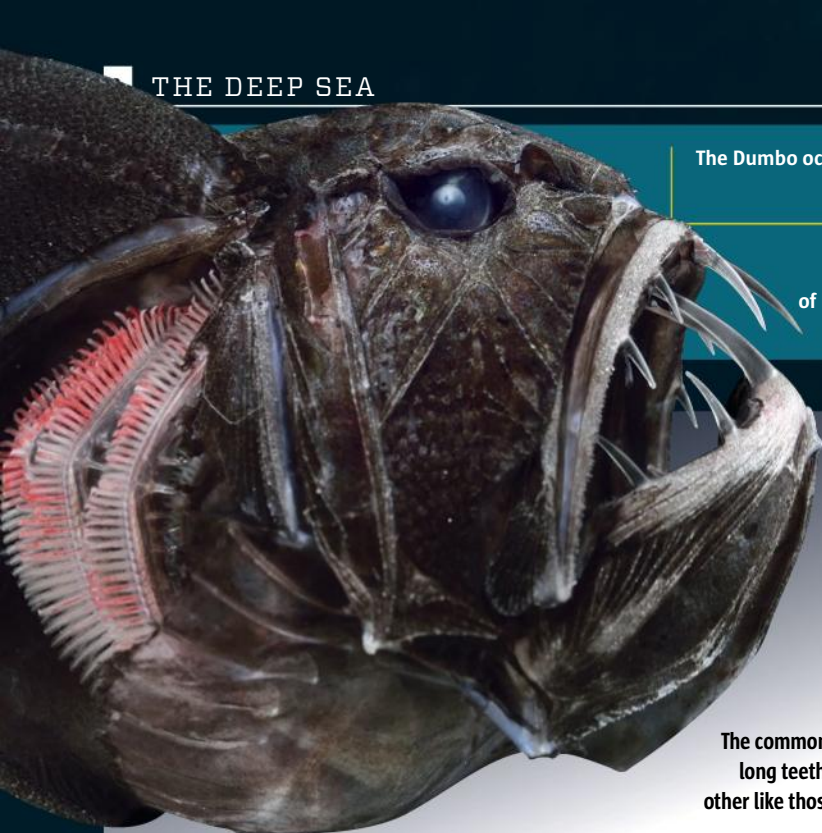


The Dumbo octopus lives at depths of down to  
**7,000 METRES**  
**MILLIONS**

of luminous bacteria make up the  
angler fish's fishing rod: esca.

**98%**

of all fish that are captured are netted  
no more than 300 km from the shore.



The common fangtooth's  
long teeth fit into each  
other like those of a zipper.

## The teeth function as a portcullis

There deep sea is sparsely populated, so when prey is finally within reach, the fish capture it in an inescapable tooth cage.

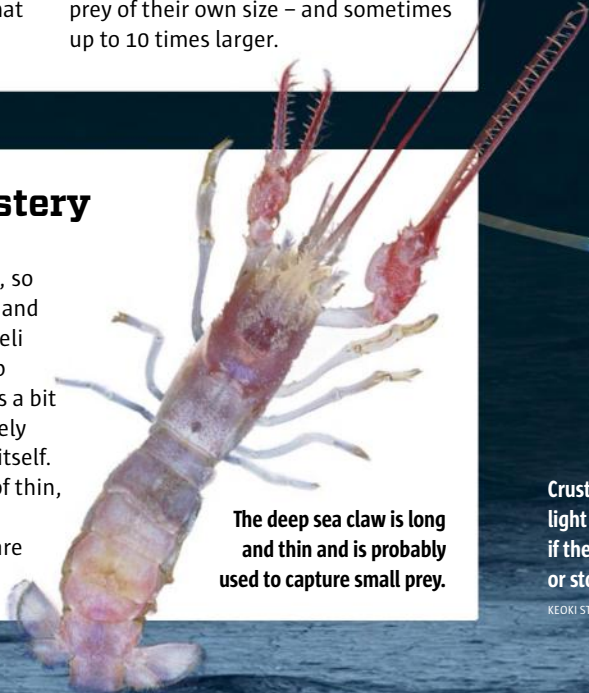
According to some scientists, deep sea fish only eat once or twice in their lives. Hence, a deep sea fish cannot afford to take any chances, when the food is finally within reach. The prey must be captured and held on to at any cost. So, a deep sea fish is often a nightmare of long, pointed teeth that stick out in all directions. When a

common fangtooth closes its mouth, the long teeth of its lower jaw fit into cavities on both sides of the brain. The mouth closes just as efficiently as the portcullis of a medieval castle, and nothing will escape.

The sparse food also means that the fish cannot be scared off by the size of the prey. So, deep sea fish are often equipped with huge mouths and stomachs that can be expanded like balloons, allowing the fish to consume prey of their own size – and sometimes up to 10 times larger.

## Huge claw is a mystery

The deep sea does not include tremendous, forceful water motion, so the animals can develop extra long and thin limbs. The *Dinochelus ausubeli* lobster, which was captured in deep waters off the Philippines in 2010, is a bit of a mystery. Its one claw is extremely long, almost as long as the lobster itself. The claw, which is narrow and full of thin, pointed teeth, is probably used to capture prey. Closer examinations are to reveal which prey it is.



The deep sea claw is long  
and thin and is probably  
used to capture small prey.



Crustaceans can use their  
light qualities as a defence,  
if they end up in the mouth  
or stomach of a predator.

KEOKI STENDER/MARINELIFEPHOTOGRAPHY.COM & NOAA



The rare megamouth shark owes its name to its mouth that is

**1.3** METRES WIDE

The bluntnose sixgill shark is more closely related to fossils than modern peers and has existed for about

**200** MILLION YRS

Of all deep sea fish, long-railed fish are believed to make up

**15%**

# Let there be light

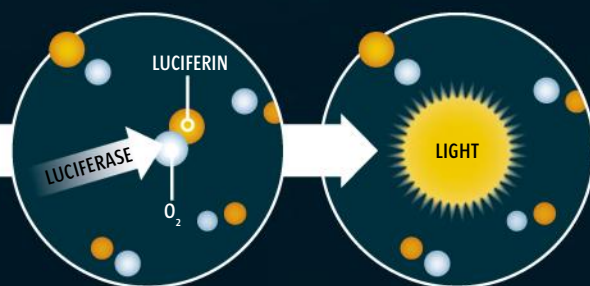
The deep sea is very dark, so either the animals must have top-notch sensory organs or produce their own light.

Biological light – bioluminescence – is known from many different groups of animals and plants, but deep sea creatures are experts. The light is used to tempt prey and mates to come closer, to scare or blind enemies, or as camouflage. Moreover, some animals even have their own flashlights that they use to navigate, when they hunt. The light can

be emitted from the entire body. Some fish spit a luminous material out of their mouths or shoot luminous excrements from their hind parts, whereas deep sea octopuses emit luminous ink. The biological light is either produced by symbiotic bacteria that live in special colonies inside the animals or by enzymes in the animal itself.

## Enzyme boosts light show

The main principle of most luminous organisms is a process, by which luciferin is oxidized, when the luciferase enzyme is affected. The process produces light and the oxyluciferin waste product.



Luciferin and oxygen (O<sub>2</sub>) exist inside the animal. To light it up, the luciferase enzyme is activated.

The luciferase makes oxygen and luciferin react with each other. When luciferin is oxidized, it lights up.

## Luminous spit made of crustaceans

The deepwater cardinalfish has a special trick that attracted attention, when it was observed and filmed for the first time. The small fish can spit light out of its mouth – probably trying to scare off enemies. That was the first theory about the phenomenon, but in reality, the spitting is much more complex.

**1** Cardinalfish feed on small creatures, so when an ostracod swims past, it is swallowed. Subsequently, the ostracod activates its only defence: light.

**2** As cardinalfish are small and relatively transparent, the ostracods make the fish's mouth and stomach light up to attract larger predators.

**3** If the fish wishes to avoid being eaten, it must get rid of the ostracods again in the shape of a luminous gob of spit.



Cardinalfish get rid of ostracods as a luminescent gob of spit.

## QUESTIONS TO BE ANSWERED

### HOW DO ANIMALS REACT UNDER EXTREME CONDITIONS?

■ Studies of organisms in eternal cold and subjected to a huge pressure can provide scientists with useful knowledge in connection with deep sea expeditions, future space missions, etc.

### HOW DID LIFE EVOLVE?

■ Deep sea animals' adaptation to extreme surroundings can demonstrate the role of evolution, and not least the relation between life in the deep sea and life on the rest of our planet.



New  
factories  
could  
start the

# ALGA AGE

To scientists, algae are not just foul-smelling, green stains in the ocean. The tiny, green organisms are sustainable biofactories that use sunlight, water, and carbon dioxide to mass-produce rare substances. **Now, scientists intend to programme algae to make anything from cancer drugs to ...**

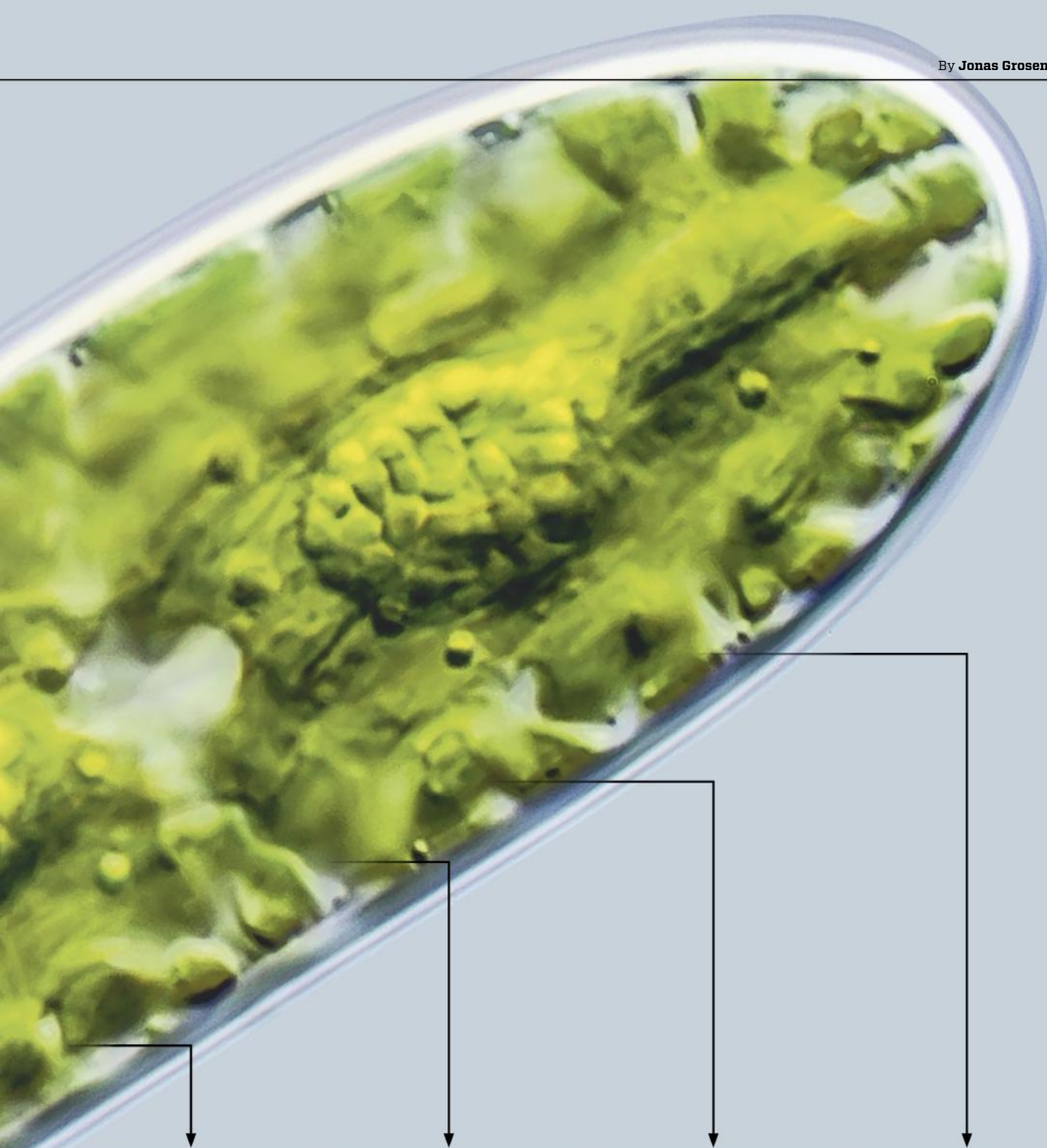
ALGA CHLOROPLASTS  
CAN PRODUCE A  
VAST NUMBER OF  
SUBSTANCES



## Cosmetic creams

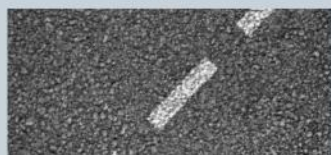
Algae naturally produce astaxanthine and beta-carotene, which are used in anti-aging products. Some moisturizers also contain the alginate alga biomaterial, which makes lipstick stick to the lips.





### Odour-free trainers

Alga-based foam is to be used in the soles of trainers to provide more elasticity and less shock effect. The foam is also anti-bacterial, restricting foul-smelling bacteria from developing in sweaty shoes.



### Water-repellent asphalt

Alga waste can be converted into a black, viscous, water-repellent mass reminiscent of asphalt. Scientists have also genetically modified algae to produce lignin, which is included in bio-asphalt made of rice or corn.



### New vaccine types

Algae can mass-produce vaccines, if scientists insert the right genes. Moreover, scientists are developing edible vaccine pills made of algae, which are less anxiety-provoking than injections.

### Paper without trees

Normally, paper is made of cellulose from trees in a polluting process. Algae will be able to make cellulose in a much more environmentally friendly way and without paper manufacturers having to use trees.



**E**ndless rows of red tubes in Southern China. From a distance, the pipes look like wines rather than top-notch industrial systems, but at the molecular level, the microscopic biofactory is working at full speed.

Located in the Yunnan province, the world's largest alga factory is run by the BGG company (Beijing Ginkgo Group), which has allocated 400,000+ m<sup>2</sup> for the growing of the *Haematococcus pluvialis* red alga. The production takes place in photobioreactors, in which the algae circulate in glass tubes, that make sure that every single alga gets the exact quantity of light and carbon dioxide needed to produce as much astaxanthin as possible. The substance is used as a nutritional supplement and an ingredient of cosmetic creams.

And that is only the beginning. Soon, pharmacists in white lab coats will be replaced by blurred alga soups that use sunlight to make valuable medication.

## MANIPULATED ALGAE MAKE DRUGS

Algae are monocellular organisms that mainly live in the ocean and can perform photosynthesis: one of the most important processes of all life on Earth. Photosynthesis is responsible for the conversion of sunlight and CO<sub>2</sub> into about any living organism. So, over the past 100 years, scientists have been busy studying the algae and their ability to take advantage of sunlight, and the studies have produced such detailed knowledge of the molecular mechanisms that solar-powered algae can be programmed to mass-produce rare and valuable substances.

Scientists use sophisticated

biotechnology to insert new genes and manipulate the algae to mass-produce substances that otherwise only exist in limited quantities in nature. The wonder molecules known as terpenoids have particularly caught scientists' attention, as a long series of natural terpenoids can kill cancer cells.

## ALGAE TO FIGHT CANCER

The terpenoid molecules boast highly complex structures and are normally very hard and time-consuming to make in the lab. But by inserting the genetic code for the production of terpenoids in alga cell nuclei, the substances can be mass-produced.

A terpenoid known as ingenol angelate can be used to fight skin cancer. The substance is only found in the resin of the *Euphorbia peplus* plant. First, the genes of the plant that code for enzymes which are responsible for the substance are identified, and subsequently, the genes are inserted into the algae. Scientists aim to use the method to produce skin cancer drugs faster and in greater quantities.

But before that can happen, scientists must programme the algae correctly. The method is almost the same as with other terpenoids, but scientists still lack the perfect way to make individual algae produce as much ingenol angelate as possible and the optimum extraction method.

## ECO-FRIENDLY ALTERNATIVE

Though scientists primarily focus on cancer drugs, the alga potential knows no limits. The Forskolin weight loss drug, which comes ▶

## DNA codes for medicine

**1** Genes from medical plants code for enzymes that produce anticancer substances known as terpenoids.

## Genes are inserted into the alga

**2** The genes are extracted from the plant and inserted into the alga cell nucleus, which will begin to produce two types of enzymes.

DNA

Plant DNA

Cell nucleus



## Plumbing

Genetically modified algae produce ethylene gas, which can be converted into polyethylene. The latter is used in almost all plastic products, from polyester sweaters to water bottles, shower curtains, and water pipes.



## "Green" fruit gum

Agar, which is produced in algae, can function as an alternative to gelatin in sweets and cosmetics, as it has gelling qualities. Today, gelatine is made of collagen, that is extracted from pig and cow tendons, skin, and bones.



## New antibiotics

Algae exists in many shapes and lives under very different conditions on both land and in the sea. Consequently, they can produce a huge repertoire of substances, and it is highly likely that future antibiotics could be found in algae.

CLAUS LUNAU/SHUTTERSTOCK



# Sunlight is fuel

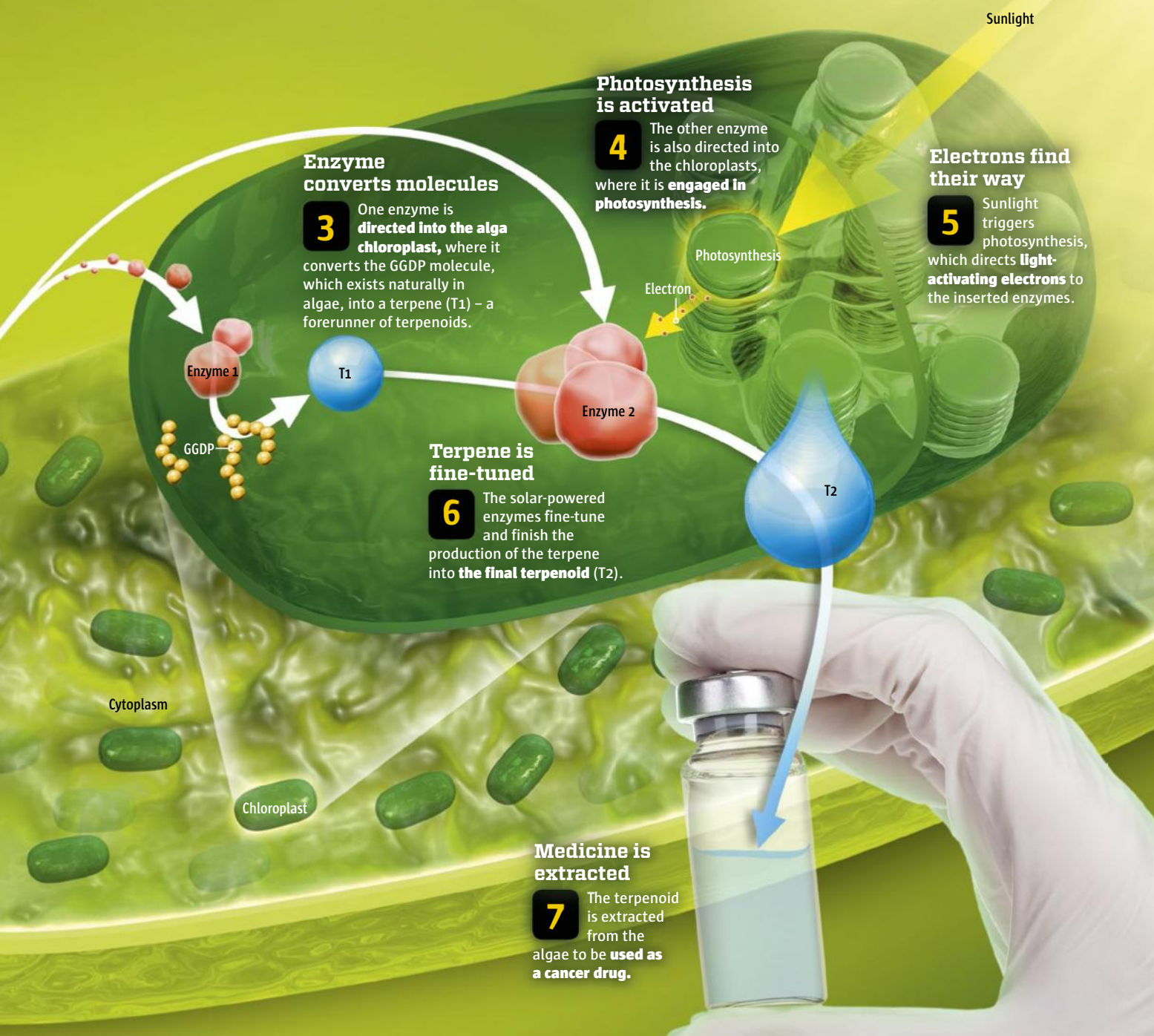
The alga factory is made up of chloroplasts. By adding specific enzymes to photosynthesis, an alga can use sunlight to produce rare substances.

If algae are to produce a specific substance such as anticancer terpenoids, they will have to be instructed precisely how to do it.

Normally, terpenoids are only produced in small quantities by special medical plants. To mass-produce terpenoids, the main computer of the alga, the cell nucleus, needs the plant's genes, which function like a recipe. The genes code for special enzymes, which – in interaction with the

biochemical alga machinery, can initiate the production of the rare terpenoids.

First, the enzymes must be inserted into the alga chloroplasts, where photosynthesis takes place. This happens by placing a signal sequence on the enzymes which makes sure that they are directed to the right place. Inside the chloroplasts, the enzymes begin to produce terpenoids, and they continue for as long as the sun shines.





► from the roots of the *Coleus forskohlii* plant, is a terpenoid that has already been successfully produced by solar-powered alga factories. And the much-coveted Artemisinin malaria drug based on the Chinese *Artemisia* annual herb is another complex terpenoid that algae will soon be able to mass-produce. It is difficult to grow the plant on a large scale, as apart from being a wonder drug against malaria parasites, Artemisinin is a pesticide that is as harmful to the environment as many banned chemicals. So, the production of Artemisinin in algae will be much more environmentally friendly.

### THE SUN IS THE ENERGY SOURCE

The operation of the biochemical alga factory requires energy. Like plants, algae are full of chloroplasts that collect energy from sunlight and trigger photosynthesis. When sunlight hits the chloroplasts, electrons are activated to trigger chemical reactions, which convert the energy of the light into chemical energy in the shape of sugar.

Scientists have found a way to use the light-activated electrons to activate enzymes that make drugs. As the enzymes originally come from plants and do not exist naturally in algae, one of the major challenges has been to get the enzymes into the chloroplasts and engaged in photosynthesis. By adding a signal sequence to the enzymes, that instructs them where to go, scientists have now overcome the challenge.

### FROM FLASK TO TANK

The shift from growing algae in small flasks in the lab to industrial mass-production in huge tanks has caused a number of practical challenges. One of the major problems of growing algae in large containers is that the sunlight will not affect algae located at the

centre of the "soup". Moreover, algae located far away from the surface have difficulties absorbing carbon dioxide, as they are surrounded by water and other algae, without direct contact to atmospheric air. On the other hand, the algae located at the surface risk being subjected to too much sunlight, which could stress them out and weaken their ability to perform photosynthesis.

The solution is alga ponds shaped like raceways. Large paddle wheels see to it that the alga mass in the pond is constantly in circulation, ensuring the algae equal quantities of sunlight and air. An alternative to open raceway ponds is photobioreactors, in which the algae are grown in closed tubes to avoid contamination and water loss.

### ALGAE CAN POWER YOUR CAR

Algae are not only useful allies in drugs, they are also used in industries manufacturing anything from cosmetics to biofuel. In theory, algae are the ultimate green energy source. They get energy directly from sunlight and remove carbon dioxide from the air. Along with water and minerals, that is all the algae need to mass-produce biofuel, but oil prices are currently so low that the alga oil is not competitive. So, algae are more profitable in the food industry.

Apart from oil, algae produce another energy source: hydrogen gas. The Toyota and Hyundai carmakers are developing a high-tech super alga, which is to produce fuel for hydrogen-powered vehicles. At this point in time, scientists have managed to manipulate algae to produce five times as much hydrogen as ordinary alga species. In the future, the gas from the tiny, environmentally friendly organisms could power hydrogen-powered cars, aeroplanes, and other engines as an alternative to fossil fuels. **SCI**

# Factory requires lots of light

When scientists build alga factories, they can choose between two versions. Although they are basically different, both versions keep the algae in motion, so they get sufficient light.



### Hydrogen fuel

Genetically manipulated algae can produce up to five times as much hydrogen as ordinary algae. Hydrogen gas can be used to power cars and is an attractive energy source due to its minimal effect on the environment.



### The best fatty acids

If dried, the *Chlorella* and *Spirulina* fresh water algae can be used as nutritional supplements, as they contain large quantities of important nutrients such as omega-3 fatty acids, vitamin B, and antioxidants.



### Seducing colours

The colour of chewing gum, slush ice, lipstick, and eyeliners is a product of red algae and the *Spirulina* blue-green alga. The algae contain colourful phyco-biliproteins, which can also be used in luminescent paint, etc.



### METHOD 1: THE EFFICIENT ONE



BEIJING GINKGO GROUP

## Red tube systems in Southern China

In a photobioreactor, closed tubes make up circuits placed on top of each other. The closed systems avoid contamination and waste of water, and they take up less space than other alga factories, but they are also more expensive. The world's largest system in Southern China includes a 400,000 m<sup>2</sup> photobioreactor that makes nutritional supplements.

### METHOD 2: THE CHEAP ONE



HAWAII OCEAN SCIENCE & TECHNOLOGY PARK

## Alga soups circulate in Hawaii

Open raceway ponds involve circulating water, ensuring that the algae get equal quantities of sunlight and carbon dioxide. The method is the cheapest way of growing algae on a large scale. One of the major systems is located on the Kona coast of Hawaii. The Nutrex company is growing red and blue-green algae in a 360,000 m<sup>2</sup> pond.



The Nutrex company in Hawaii primarily grows the *Spirulina* blue-green alga, which is a popular nutritional supplement.

NUTREX HAWAII



# SUBSCRIBE & START SAVING NOW!



## Only \$65 for 1 year!

That's 8 issues of **SCIENCE ILLUSTRATED** for just \$8.12 a copy (normally \$9.99)!





## Every issue of Australian Science Illustrated includes news and features on:

- New science discoveries
- Astronomy, cosmology and the universe
- Plant and animal biology
- Archaeology and palaeontology
- History and culture
- Green technology and renewable energy

→ And much more!

## Subscribing to Australian Science Illustrated gives you these benefits!

- ✓ Up to 25% OFF the retail price!
- ✓ Never miss an issue!
- ✓ Get the latest issue delivered FREE to your door!
- ✓ A subscription to Science Illustrated is the perfect gift!

## ORDERING YOUR SUBSCRIPTION IS EASY



[mymagazines.com.au](http://mymagazines.com.au)



Call 1300 361 146 or  
02 9901 6111



Mail  
Science Illustrated  
Locked Bag 3355  
St Leonards NSW, 1590

# SCIENCE ILLUSTRATED

YES! I WOULD LIKE TO SUBSCRIBE STARTING WITH THE NEXT AVAILABLE ISSUE

☐ Me ☐ Gift

☐ 2 Years (16 issues) **ONLY \$119**  
(Normally \$159.84) - **26% OFF!**

☐ 1 Year (8 issues) **ONLY \$65**  
(Normally \$79.92) - **19% OFF!**

☐ 6 Mths (4 issues) **ONLY \$35**  
(Normally \$39.96) - **12% OFF!**

Best  
value

### YOUR DETAILS

MR/MRS/MS/MISS Name: \_\_\_\_\_

Address: \_\_\_\_\_

State: \_\_\_\_\_

Postcode: \_\_\_\_\_

Email: \_\_\_\_\_

Phone: (    ) \_\_\_\_\_

PLEASE PROVIDE PHONE OR EMAIL IN CASE OF DELIVERY ISSUES

### GIFT RECIPIENT DETAILS

MR/MRS/MS/MISS Name: \_\_\_\_\_

Address: \_\_\_\_\_

State: \_\_\_\_\_

Postcode: \_\_\_\_\_

Email: \_\_\_\_\_

Phone: (    ) \_\_\_\_\_

### PAYMENT DETAILS

I enclose a Cheque / Money Order for AU\$ \_\_\_\_\_ payable to  
NextMedia Pty Ltd

OR

Please charge \$ \_\_\_\_\_ to ☐ VISA ☐ MasterCard

Card holder's name: \_\_\_\_\_

Card number:

Expiry date:   /   CVV:

Signature: \_\_\_\_\_

Terms and conditions: Price offer available to Australian and NZ residents. Expires 23/11/16. Includes GST. Savings based on total cover price. Overseas Airmail 16 issues A\$199 or 8 issues A\$109. This form may be used as a tax invoice. nextmedia Pty Ltd ABN 84 128 805 970. Please tick if you do not wish to receive special offers or information from nextmedia or its partners via ☐ mail ☐ email. Please refer to [www.nextmedia.com.au](http://www.nextmedia.com.au) for the full Privacy Notice.

MA/49



## 5 vital experiments

In recent years, experiments have proved fat's terrific capacity over and over again. Fat cannot only repair damaged bones and muscles, it can also activate healing processes in the body.



### 1 Delays rejection of transplanted organs

In 2014, a team of scientists transplanted human skin to rats, which rejected it. But if the transplant included fat stem cells, the skin was rejected more slowly.



### 2 Optimises the pancreas of a diabetic

The insulin producing cells of diabetics are gradually destroyed. In 2015, a rat experiment revealed that fat stem cells nurse the sick cells, making the production continue.



### 3 Heals open chronic wounds

Large, open wounds healed faster in rats, into whose wounds scientists injected fat stem cells in 2016. The stem cells made new blood vessels grow in the wound.



### 4 Revives heart muscles following coronary thrombosis

After coronary thrombosis, some of the heart muscles die, weakening the pumping function. In 2016, scientists showed that fat stem cells can regenerate mice hearts.



### 5 Makes bones self repairing

In an experiment from 2011, fat stem cell made damaged rabbit bones regenerate. Bone cells help, but the stem cells make them more active.



The potent cells exist in perfectly ordinary fat and can be harvested in connection with liposuction, etc.



# FAT IS THE NEW BLACK

Are you tired of your stomach fat? Don't be. According to new experiments, the human body's fat deposits are ripe with potent cells, which can repair anything from wounds to heart damage. Fat itself may not be the enemy...



**F**at! You may soon risk that your doctor makes this remark, when you are hospitalised with coronary thrombosis. But don't worry. She is not gleeful. The doctor just explains what she is going to prescribe in order for your impaired heart to repair itself and get over the disease.

Fat – or rather stem cells – is well on its way to becoming the new universal drug that is much better than all other treatments, when a wound will not heal or your heart is weak. Whereas other stem cells are difficult and risky to obtain, our fat deposits include lots of easily accessible stem cells, suddenly turning fat into a miracle drug.

#### WASTE IS FULL OF STEM CELLS

Stem cells are unique, as they can develop into other specialized cell types, whereas skin cells

can neither divide nor take on other types of tasks than the original one. So, stem cells can be used to repair damaged tissue in body muscles and bones.

Since the world's first bone marrow

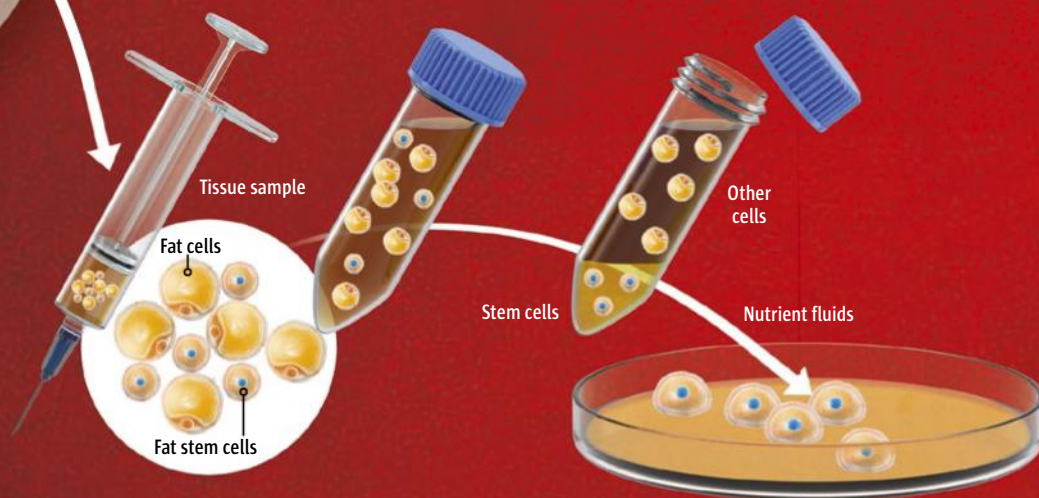
**30 billion**

**fat cells exist** in the human body. Losing weight does not reduce this number.

transplant in 1957, bone marrow stem cells have been scientists' favourites. However, scientists did not realize the existence of fat stem cells until after 2000. The cells are

## Stomach fat heals the heart

The human body is ripe with fat deposits that are full of stem cells. In just 1.5 months, the stem cells can develop into highly specialised cells, which doctors can use to repair damaged tissue in the heart, etc.



#### Fat tissue extracted

**1** A needle is used to take a tissue sample from the fat layer right beneath the skin. The tissue consists of large fat cells and many small fat stem cells.

#### Stem cells isolated

**2** The tissue sample is treated with enzymes, that detach the cells from each other. The dissolution is centrifuged, so the stem cells sink to the bottom.

#### Cell growth

**3** Scientists grow the fat stem cells in nutrient fluids, so they divide and are able to develop into other body cell types.



located among the fat cells and much smaller, but still make up about 1 % of all cells in the numerous fat deposits of the human body. That makes them more than 1,000 times as common as bone marrow stem cells. Harvesting stem cells from the bone marrow is also very difficult, and it could involve a risk. In the case of fat stem cells, it is quite the reverse. In the US alone, 400,000 people have liposuctions annually. Today, the many tonnes of fat are considered to be a waste product, but they could easily be used for large-scale production of stem cells.

### SCIENTISTS ONLY TESTED ON ANIMALS

Fat stem cells are not only easier to obtain than their "sisters" in the bone marrow, they are also superior in several other ways.

In 2013, a Dutch scientist compared the

two types of stem cells, concluding that fat deposit stem cells not only grow faster in the lab, they are also better at suppressing the immune system. That is a special characteristic about stem cells that a team of scientists came to suspect in 2001, when they transplanted a piece of skin from one baboon to another, discovering that the skin was not rejected as quickly, if the foreign skin was accompanied by stem cells. A similar conclusion was made by a Japanese scientist in 2014, when he transplanted new kidneys into a group of rats, discovering that fat stem cells delayed rejection.

If fat stem cells can also prevent foreign organs from being rejected after a transplant in humans, it could be very important. Every year, more than 30,000 organ transplants are carried out in the EU alone, and the patients must use

immune-suppressive drugs for the rest of their lives to prevent their organs from being rejected. Nevertheless, the organ will be rejected one day, requiring a new transplant, which is not only expensive, but also dangerous.

## 15 per cent

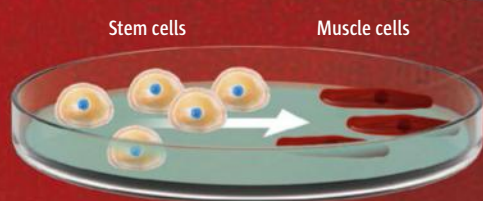
**of the brain is fat.** It is located as a layer surrounding individual brain cells.

The discovery of the beneficial characteristics of fat stem cells is new and has so far particularly been tested on animals. But in the US alone, more than ►

### Bones are defeated by fat

Fat deposit stem cells possess many of the same qualities as their bone marrow "sisters", but they are much easier to obtain.

	Fat	Bone marrow
Produces new cell types	✓✓✓✓	✓✓✓✓
Quantity in the body	Many in many places	A few in one place
Harvesting opportunity	Yes indeed	Relatively poor
Risk when harvesting	Very slight	Relatively high
Easy to grow in the lab	✓✓	✓

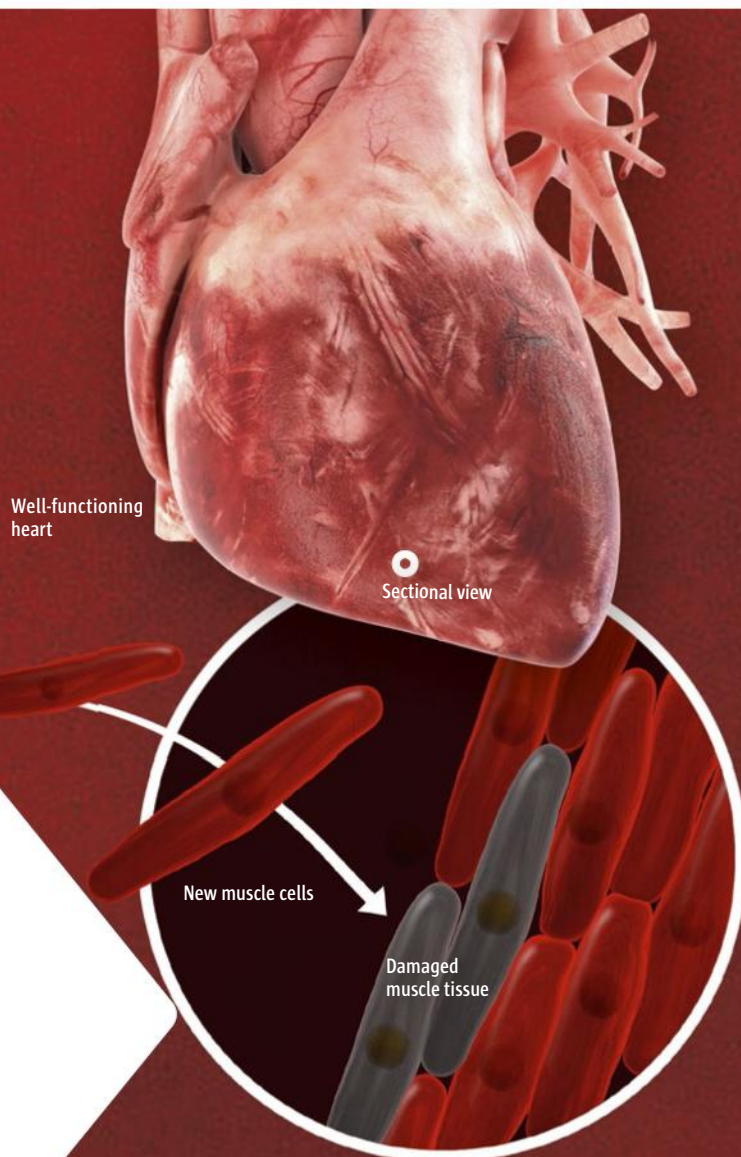


### Cell specialization

**4** If the stem cells are to replace damaged cells in the heart, scientists add special substances to make them develop into blood vessels, muscles, etc.

### Heart repaired

**5** The new, specialized cells are harvested and injected into the body to replace damaged muscle tissue in the heart, etc., over time.





► 100 experiments with people are already going on or being prepared. The experiments are the first step towards developing new treatments against different diseases such as arthritis, multiple sclerosis, Parkinson's, diabetes, and the COPD lung disease. But no concrete results are available yet.

When scientists grow stem cells in the lab, they control the development of the cells by adding different substances to the fluid, in which the cells grow. The substances are molecules that bind to the cell and activate and deactivate selected genes in the core in a highly coordinated pattern. In this way, scientists can make fat stem cells convert into bones, muscles, blood vessels, etc.

## 25 hormones

**are produced by fatty tissue.**

They regulate the immune system, etc.

### WIDE MOUSE HEART BLOOD VESSELS

This was demonstrated by Japanese scientists in 2016. Six weeks after having subjected a group of mice to cardiac arrest, the majority of the animals' heart muscles had withered and been replaced by scar tissue, which weakened the pumping of the heart. However, some of the mice's hearts had been injected with fat stem cells, which had developed into muscle cells to replace the scar tissue in the muscles, making the heart stronger.

In other experiments, scientists were able to make the fat stem cells develop into specific types of tissue. If, prior to the injection, the cells were bathed in a specific protein, the TGF- $\beta$  peptide, they developed into the small muscles of the heart that are located around the blood vessels and regulate the blood supply by changing the diameter of the vessels. If, however, scientists added the hVEGF peptide, the stem cells turned into the cells that line the inside of the blood vessels, whereas the SMIM nutrient liquid converted them into heart muscle cells.

### CELLS SEEK OUT THE DAMAGE

Sometimes, scientists even do not need to make the fat stem cells develop into something particular, as demonstrated by a Pakistani team of scientists in 2016. They injected fat stem cells into the knees of rats with osteoarthritis and were able to watch the stem cells develop into cartilage cells, restoring the worn-out cartilage layer in the knee.

In some cases, the fat stem cells seek out the damaged area themselves, if injected into the blood vessels. In an experiment with mice with muscular atrophy carried out in 2014, the animals were injected with fat stem cells, which found their way to the sick muscles all by themselves. The US scientist behind the experiment was even able to show that the cells did not develop into muscle cells that replaced the sick cells. They remained fat stem cells, which cured the muscle cells by liberating a protein that the mice lacked.

In recent years, many scientists have come up with similar results. The immune system functions by some neurotransmitters stimulating inflammation processes, whereas others reduce them. The right mixture of neurotransmitters ensures that the immune system keeps the body healthy, but sometimes the balance fails to exist, so the system does not function optimally, and that could cause chronic wounds and diseases such as diabetes. The fat stem cells have proved to have a healing effect. It is a mystery what the stem cells do, but scientists think that the cells liberate the special neurotransmitters.

Likewise, fat stem cells also stimulate the formation of blood vessels and red and white blood cells and prevent programmed cell death.

### SCIENTISTS "RESET" FAT

The stem cells in our often slightly too large fat deposits involve a huge potential – not least because they are so easy to obtain. And in April 2016, the future prospects improved even more.

By then, scientists from the University of New South Wales, Australia, managed to convert ordinary fat cells – of which we typically have about 15 kg in our bodies – into stem cells. And even to a particularly potent version of stem cells that can develop into basically any type of body cells. The Australian scientists used the 5-Azacididine chemical, which "reset" fat to forget their original task and return to the universal starting point which is characteristic of stem cells.

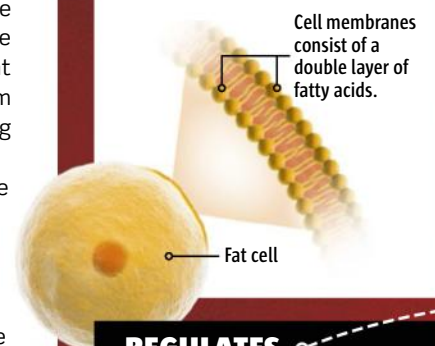
The Australian scientists aim to test the new stem cells on humans in 2017. They still do not know if fat stem cells work on humans, but if the new experiments are successful and the development continues, a bit of extra stomach fat could save you. **Sci**

## BUILDS

### Holds cells together

Much body fat is made up by fatty acids located in a thin layer around the cells, which they delimit and hold together. Brain nerve cells include lots of fat, as it accelerates the speed of nerve signals.

Cell membranes consist of a double layer of fatty acids.



## REGULATES

### Maintains the immune system

Fat tissue is not only passive deposits, but active organs that produce oestrogen, leptin, and about 25 other substances. They affect the entire body and regulate metabolism, immune system, and more.

## STORES

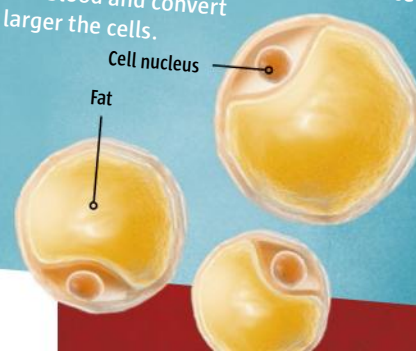
### Stores the body's surplus energy

Fat is better than carbohydrates and protein at storing surplus energy after a meal. Fat contains more than twice as much energy, and it does not bind water, restricting the size of the body's energy deposits.

## Liquid fat makes a cell large

The fat deposits are a type of connective tissue located beneath the skin. One single fat cell has a diameter of only 0.1 mm, and it almost only includes fat in a partly liquid state. The more energy-rich nutrients the fat cells absorb from the blood and convert into fat, the larger the cells.

Apart from a small cell nucleus, a fat cell contains a large drop of liquid fat.





# 15 kg of fat benefits the body

Fat has a bad reputation, but actually, the 15-20 kg of fat that a healthy body contains serves many vital purposes. If the fat cells grow too large, however, they may release harmful neurotransmitters.

## HEATS

### Re-directs production

Normally, the cells convert nutrients into the ATP molecule, which powers different processes in the body, but brown fat can derail the production of the molecule, burning the energy in the shape of heat instead, if the body is cold.

## THREATENS

### An apple-shaped beer belly is bad

Beer belly fat is not located beneath the skin like ordinary stomach fat, rather it surrounds the internal organs. It releases aggressive signal molecules and boosts inflammation.

Lots of fat around the organs increases the risk of cancer, etc.

## INSULATES

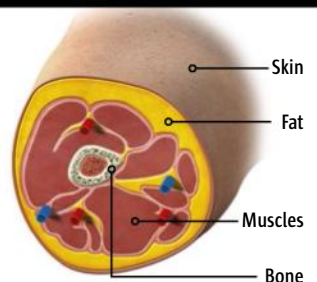
### Protects against cold

With a body fat percentage of 50+, polar bears can keep warm in the freezing Arctic Ocean, as the fat beneath the skin insulates well. Though the body fat percentage of humans is only half of that, fat plays an vital role, when it comes to protecting us from the cold.

## PROTECTS

### Absorbs blows from the surroundings

Without our well-padded bottoms, sitting down would hurt, so a 1-2 cm layer of fat right beneath the skin makes up a pleasant cushion. A thinner fat layer in the rest of the body also protects us against blows, so we do not hurt ourselves all the time.

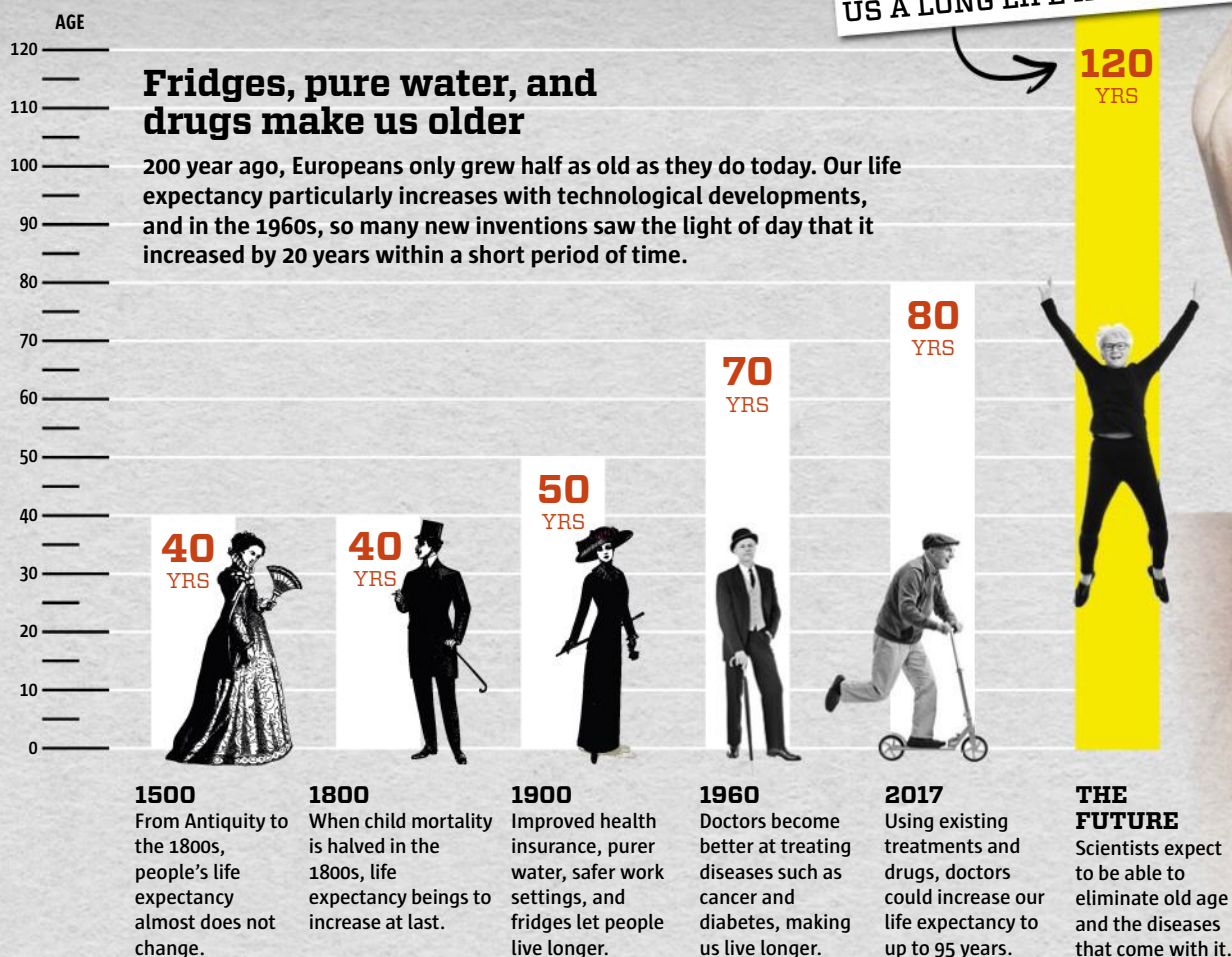




# FOREVER YOUNG

120 years in a young body – that is what scientists aim to give us. Many years of studies have taught them why we get old, and now, they are making youth elixirs with stem cells, special genes, and drugs that can keep us young throughout life.

IN THE FUTURE, SCIENTISTS WILL GIVE US A LONG LIFE IN A YOUNG BODY.







Scientists aim to prolong our lives, so  
we will get more years in perfect health.

SHUTTERSTOCK & LIAM NORRIS/CULTURA/GETTY IMAGES

A virus attack is something that most people would like to avoid, but in Madrid, a most welcome virus is spreading in 35 lab mice; a virus that makes them younger. The animals were well on in years, when they were infected, but already after two months, the signs of ageing slowly disappear. The mice's bones strengthen, their blood sugar levels stabilize, and their muscles move with the accuracy of young mice. The virus has entered the mice's cells, turning back the cells' genetic clocks, so the animals not only get the strength of their youth back, they also live no less than 13 % longer.

The woman behind the experiment is molecular biologist María Blasco from the Spanish National Cancer Research Centre. In 2012, when she injected her youth virus into the blood vessels of 35 mice, it was the beginning of a new era in age research.

So far, scientists have managed to increase people's life expectancy by about 30 years via improved treatment of the diseases that kill us when we get old. Now, they aim to find a cure against old age itself. By preventing the body from developing diseases such as dementia, cancer, and arteriosclerosis, they aim to give us long lives in healthy bodies. The research of the past century has answered the question of why we get older, and now, scientists armed with stem cells and new gene therapies can reverse the processes that wear down the body from within. In labs throughout the world, several youth elixirs are under development. Very recently, scientists even discovered that the most promising cure against ageing has already been tested and sits in the medication cabinets of millions of people throughout the world

### SCIENTISTS READ GENETIC CLOCKS

To beat death, scientists spent years trying to understand what old age is. They studied how, throughout life, we wear down our bodies and their cells, which slowly get to function ever more poorly, perform worse, and are affected by errors. After a long life, the heart will begin to pump more poorly, as the number of heart beats wear out the organ's muscle cells. Similarly, the brain thinks more slowly and remembers more poorly, as neurons give in one by one. In the end, the body is so weak and sick that it dies. So, a youth pill must prevent cells of the entire body from decaying, which was the idea behind María Blasco's experiment. In the lab, she designed a virus that infected all cells in a mouse and added an extra gene.

The cells of all mammals contain a genetic clock. At the end of our chromosomes, you will find telomeres, which become slightly shorter every time a cell divides. Consequently, the ►



# Starvation diet rejuvenates old cells

Today, scientists have a very accurate understanding of why we get old, and now, they also have concrete ideas of how to stop cell ageing.

## RENEW STEM CELLS

When body cells become old and worn, they die, and stem cells replacte them by new ones. But at one point, no more stem cells remain.

✓ With new drugs, scientists can make our stem cells live longer or grow new ones in the lab for us.

## CLEAN UP CELL

Worn-out proteins and other waste accumulate in our cells, which cannot always get rid of everything themselves.

✓ Spermidine, which exists in food, etc., helps cells clean up via a process known as autophagocytosis.

## CONTROL BLOOD SUGAR

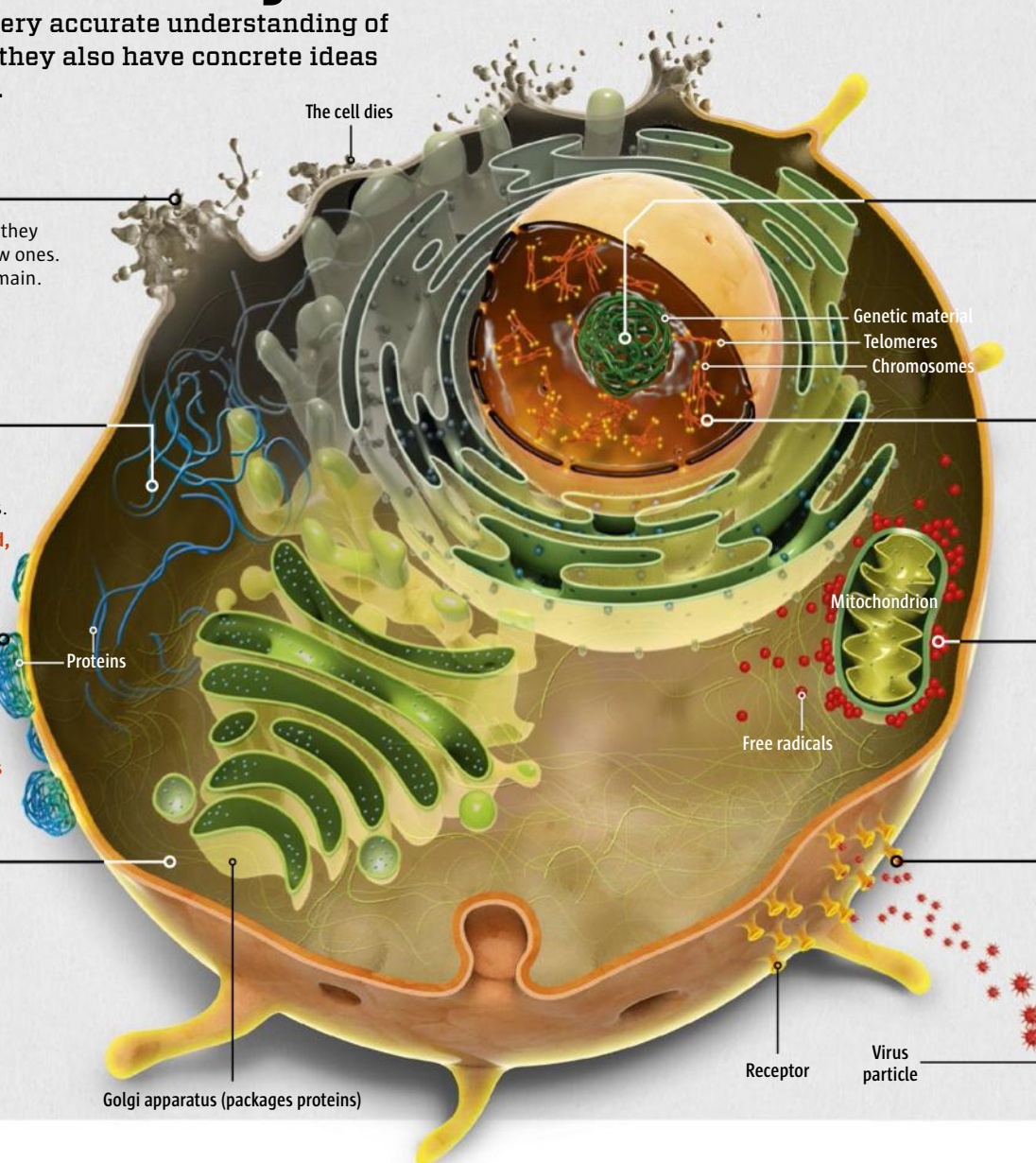
Sugar in our blood makes proteins stick to the cell, increasing the risk of arteriosclerosis.

✓ A healthy diet and specific drugs can help body cells absorb the sugar that exists in the blood.

## EAT LESS

Calories, proteins, and special amino acids in our food wear down body cells, making them die faster.

✓ If we consume fewer calories than the body needs or are vegetarians, the cells live longer.



► length of the telomeres reveal the age of our cells. When the telomeres have been "spent", the cell dies, leaving the body weaker and older. However, the telomerase enzyme can extend our chromosomes, delaying cell death. Unfortunately, we do not have enough telomerase in our cells to overcome the ravages of time, and so, the chromosomes slowly become shorter, until we die.

María Blasco cheated old age by using virus to fill her test animals' cells with extra copies of the gene that codes for telomerase. In this way, she slowed down the pace of the

mice's genetic clocks and prolonged their lives by almost six months. In humans, the effect would be like increasing life expectancy by 10 years to an average of 90.

### 44-YEAR-OLD IS 20 YEARS YOUNGER

One woman is so convinced that telomerase prolongs life that she has volunteered her body to the most recent experiments. 44-year-old Elizabeth Parris is the CEO of the American company BioViva, and in 2015, she flew to Columbia to undergo gene therapy with telomerase. According to the company's

website, the CEO's telomeres are already 9% longer, meaning that she is 20 years younger. However, there is no scientific documentation to support the claim.

### CELL POWER PLANT CAUSES WRINKLES

Telomeres are not the only factors that control the decay of the human body. Inside our cells, you will also find small power plants, known as mitochondria, that produce energy for the cell, but also emit harmful waste products in the shape of free radicals. The chemical compounds break down proteins and harm



## REPAIR DNA

With age, our cells store mutations and other changes of their DNA, which harm the genes and make us get older.

- ✓ **Gene treatments and some drugs can repair DNA damage, allowing our cells to live longer.**

## EXTEND CHROMOSOMES

Chromosome ends, also known as telomeres, become shorter, each time a cell divides. Once they have been used up, the cell dies.

- ✓ **Gene therapy and special hormones can extend the telomeres and hence make the cell younger.**

## CURB POLLUTION

Free radicals are waste products from cell mitochondria. The radicals attack and shatter cell DNA and proteins.

- ✓ **Some drugs have proved to be able to limit the number of harmful metabolism waste products.**

## STOP INFLAMMATION

Viruses and other irritation cause inflammation. If the inflammation becomes permanent, we could develop diabetes, cancer, etc.

- ✓ **Stem cells and special immune system signal molecules can defeat harmful inflammation.**

DNA. If they attack skin cells, we get wrinkles, if they affect the internal cell layer of blood vessels, we could develop arteriosclerosis, and if lung cells are filled with free radicals, they could mutate into cancer cells.

## IMMUNE SYSTEM CONSUMES US

The antidote against free radicals is antioxidants which exist in fruit and vegetables. Antioxidants can tolerate attacks by free radicals and so protect a cell's vulnerable DNA and proteins. Hence, they could be an efficient cure against the diseases

that kill us, when we get older. Scientists have carried out numerous experiments with roundworms, fruit flies, mice, and rats, which were fed lots of antioxidants from vitamins, red wine, turmeric, etc. In several of the experiments, the animals lived about 10 % longer, but just as many had no effect.

Consequently, it was a dead end, until 2016, when scientist Gustavo Barja from the Complutense University in Madrid, Spain, managed to defeat free radicals with controversial means. He halved the polluting effect of free radicals in the cells of middle-aged mice by means of a drug that is already in use. Rapamycin is prescribed for patients who have received a new organ, and the drug makes sure that the body does not reject a newly-transplanted organ by dampening the immune system.

Another scientist, Richard Miller from the University of Michigan, used the same drug to prolong the lives of male mice by 23 %, whereas "his" female mice lived no less than 26 % longer. And in Texas, a third team of scientists are testing the drug on Callithrix monkeys, before moving on to experiments with humans. They believe that they can use rapamycin to make a pill that can give us another 20 years of life.

## VERY OLD PEOPLE HAVE YOUTH GENES

To scientists, rapamycin was a totally unexpected surprise, as it dampens the body's defence against diseases. However, it turns out that the immune system plays a key role in the slower decay of the body. When the system repairs damage to organs or heals wounds, it triggers inflammation – a chain reaction in which a series of signal molecules replace each other to repair the damage. The reaction is indispensable, but unfortunately, it can get out of control, and permanent inflammation in the body could develop into severe diseases such as diabetes and cancer.

If scientists are to eliminate the major life style diseases, it will be wise to take a closer look at the immune system, and that was what Calogero Caruso from the University of Palermo, Italy, did in 2003, when he gathered 72 100+-year-old people to analyse their genes. He compared the genes to samples from people of the ages of 22-60 and discovered that the old people had special versions of two genes. One gene "turns up" the IL-10 neurotransmitter that dampens inflammation, whereas the other "turns down" TNF-alpha, which boosts inflammation. Since then, other experiments have also demonstrated that substances which dampen

## EVER MORE AGE RECORDS ARE SET

# 122

**YEARS WAS THE AGE OF THE WORLD'S OLDEST PERSON - JEANNE CALMENT OF FRANCE.**



AFP/SCANPIX

# 17 272

**% of the world population will be 65+ years old in 2050, whereas only 7 % will be less than five years old at the time. Right now, the two groups are the same size.**

**years is how old a bowhead whale can grow, making it the longest-living vertebrate. Jelly-fish are considered to live forever, as they can restart their life cycles.**

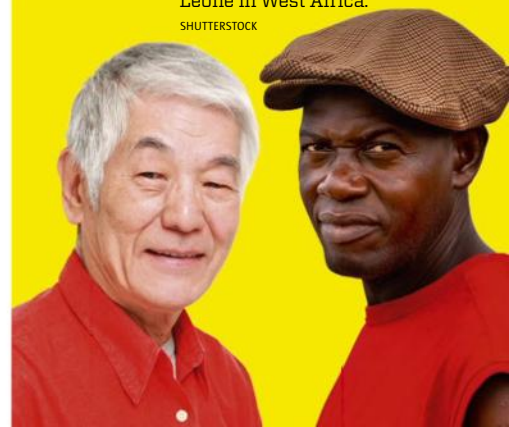
# 455,000

**people are 100+ years old today. In 2050, scientists expect there to be no less than nine times more.**

# 33.6

**years is the difference of life expectancy of Japanese citizens and the people of Sierra Leone in West Africa.**

SHUTTERSTOCK





► inflammation could give us longer lives, whereas those that boost them have the opposite effect. So, scientists have identified specific substances that not only fight old age, but also the diseases that follow from it. Several companies are now growing stem cells that both liberate and "turn down" the very right substances. An American biotech company recently announced plans of extracting stem cells from our spinal marrow or fat deposits, growing them in labs, and injecting them into our blood vessels, halting all harmful inflammation.

### EXISTING DRUG MAKES US YOUNGER

But much to their surprise, scientists have discovered that the most promising source of youth is a highly common one: the metformin diabetes drug.

In 2013, Kevin Struhl from the Harvard Medical School in Boston, USA, discovered that the drug deactivates a number of genes that code for substances

which boost inflammation. In the same year, another scientist, Rafael de Cabo from the National Institutes of Health in Baltimore, USA, demonstrated that if he fed mice a little metformin every day, they lived about two months longer than expected. However, the major eye opener came in 2014.

### SCIENTISTS AIM TO GIVE US 30 YEARS


The medical records of 78,241 diabetes patients who took metformin were studied over a period of seven years by Craig Currie from the British Cardiff University. Currie expected to find that the diabetics would generally die before healthy people, but that was not the case. The people who had diabetes – which could cause cardiovascular disease, wear down nerves, harm kidneys, and make patients blind – lived no less than 18 % longer than the healthy ones.

The results have given Professor Nir Barzilai from New York new faith. Last year, he applied for the American authorities' permission to let him test metformin on 1,500 healthy people aged 65-79 to see if

they live longer and better than elderly people who do not get the drug. Nir Barzilai hopes that following the experiment, he will be able to develop a simple cure that can make us live 15-30 years longer.

He also thinks that metformin protects brain cells against Alzheimer's and improves our capacity to think by up to 30%. So, he aims to prolong our lives and give us more years in good health by means of a drug that has already been approved for use.

### TAKE A STEM CELL CURE AT 80

A race is going on, and considering all the ideas, it is only a question of time before the first youth pill will be available. In the future, you may keep age away by starting gene therapy with telomerase in your 40s, take pills with metformin and rapamycin, when you turn 60, and spoil yourself for your 80th birthday with a stem cell cure that repairs all bodily defects. However, it remains to be seen, whether the treatments can be combined to prolong our lives by up to 60 years. And what would you do with all that time? 

At the age of 93, Tao Porchon-Lynch from New York was named the world's oldest yoga instructor. Her ageing body can still manage demanding exercises.

# Elixir of life pills

In drugs and food, scientists have discovered several promising substances that make test animals live longer. In the years to come, they will test their elixirs on humans.

5

POSSIBLE ELIXIRS OF LIFE

ELIXIR	EXISTS IN	EFFECT
<b>Spermidine</b>	Food such as beans, cabbage, cheese, wholegrains.	Cleans up molecular waste in body cells.
<b>Vitamin E</b>	Food such as nuts, avocado, vegetable oil.	Limits the damage done by free radicals.
<b>Resveratrol</b>	Food such as grapes and turmeric.	Reduces inflammation and zaps free radicals.
<b>Rapamycin</b>	Drugs for people who have had organ transplants.	Curbs the immune system.
<b>Metformin</b>	Diabetes drugs.	Stabilizes the blood sugar level by affecting liver cells, muscle cells, etc.





# We age differently

Based on measurements of your BMI, blood pressure, and other body values, a computer can quickly calculate your biological age. It could be decades from your actual age.

Age is only a number, they say. Gene researcher Daniel Belsky from Duke University in the US proved that it is true in 2015, when he developed an **easy method to calculate the age of a human body**, or our biological age, that is.

In a major study, he measured reliable signs of age in 954 people from their 26th to their 38th years. He measured how well the kidneys functioned, how well the heart pumped blood, and how efficiently the immune



IDENTICAL TWINS

Two people of the same age have not aged to the same extent. Mutations, etc., could boost ageing in one of them.

system defeated threats. To find a more simple measuring method, his team simultaneously tested blood pressure, BMI, cholesterol, etc. Finally, a computer programme was fed all the data. **The programme found a simpler model**, which calculates your body's biological age based on 18 values.

Although all test subjects were 38 years old, some of them had a biological age of 47, whereas the bodies of others could be compared to those of 28-year-old people's.

117

% is how much life expectancy has increased over the past 100 years.

115 3.8

years is the highest average life expectancy possible at this time, according to some scientists. Others think that we can do better than that.

years is how much Americans can add to their lives, if none of them were fat.

4.6 years. That is how much the average woman lives longer than the average man.



IN ROUNDWORMS

IN FRUIT FLIES

IN MICE

IN HUMANS

15 %	30 %	-	Prolongs the life of cells grown in the lab
20 %	15 %	40 %	Some experiments result in 10 % longer life, whereas others have no effect.
18 %	29 %	31 %	Experiments indicate that the elixir could give us a longer and more healthy old age.
19 %	26 %	26 %	Still uncertain. Scientists are testing the elixir on a closely related monkey.
36 %	-	38 %	

ELIXIR  
PROLONGS  
LIFE  
BY:

Diabetes patients, who have taken metformin, live 18 % longer than healthy people.





# Extreme heat makes cities uninhabitable

In the warmest regions of the world, summer heat records are set all the time. Scientists warn that some countries are going to experience lethal temperatures, now that global warming seeming inevitable.

In 2070, extremely high temperatures could make cities on the Persian Gulf uninhabitable.



## Heat and humidity: a fatal cocktail

Our bodies sweat to be cooled, but the cooling effect depends on air humidity. The higher the level, the less water can evaporate. By wrapping a thermometer in wet cloth, you will get the wet-bulb temperature, which is the temperature to which sweat is able to cool the body at the existing air humidity level.

**1** A thermometer consists of a liquid that expands as temperatures rise and contracts as temperatures fall.

NORMAL THERMOMETER WET-BULB THERMOMETER

**3** Hence, the wet-bulb temperature is a measure of how much sweat can cool the body. Temperatures of 35+ degrees are lethal.

**2** If a thermometer is wrapped in wet cloth, it will measure a lower temperature. When the liquid evaporates, it takes away energy and so also heat.

In July 2016, when a weather station in North-Western Kuwait measured 54 degrees, it may have been the highest temperature ever recorded on Earth. The potential record was set during an unusually hot summer in the already warm Middle East and North Africa.

In Morocco, thermometers suddenly indicated at temperature of 46.7 degrees, in Saudi Arabia, people were struggling with temperatures of 50+ degrees, and in Basra, Iraq, temperatures came close to those in Kuwait with 53.9 degrees.

For decades, scientists have been able to see that human activities are changing Earth's climate drastically. Throughout the world, one

heat record is followed by the next, but in the countries on the Persian Gulf, the climate change is so extreme and develops so fast that the major cities could literally become uninhabitable this century.

That was the gloomy prediction in a study by scientists from the Massachusetts Institute of Technology and Loyola Marymount University published in the *Nature Climate Change* journal in 2015. The study focused on the wet-bulb temperature, which is a measure of heat that – unlike ordinary temperature readings – includes air humidity. A wet-bulb temperature of 35 degrees is considered the limit of human survival. If the temperature is higher than that, the combination of extreme heat and

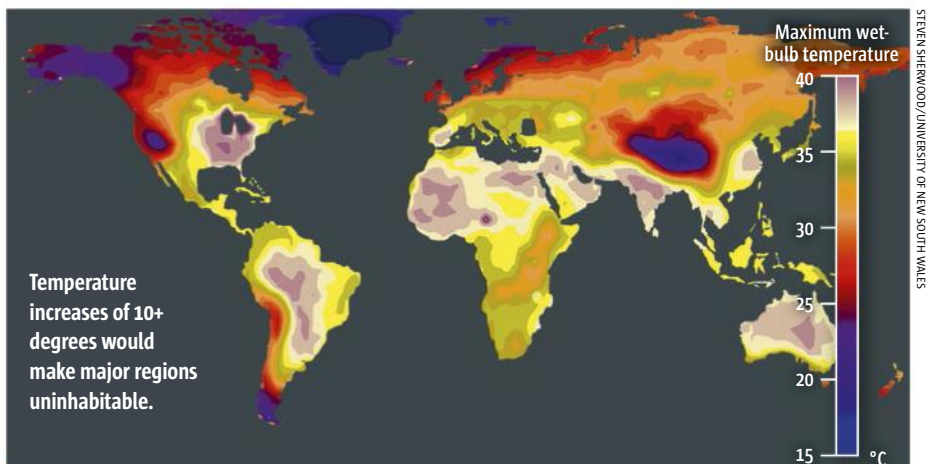
high humidity will mean that the body is no longer able to cool itself and give off heat via sweat. Even healthy people will only be able to survive outside for a few hours.

However, this limit could be reached in cities on the Persian Gulf in less than 100 years. According to the study, the people of Dubai, Abu Dhabi, and Doha will be among the first to feel the severe consequences of global warming. According to the scientists' calculations, after 2017, the people living along on the Persian Gulf coast will experience summer days every or every second decade with wet-bulb temperatures that exceed the human limit.

### HEAT WAVES ARE MORE COMMON

The changes in the Middle East and North Africa are among the most concrete and dangerous consequences of climate change, but throughout the world, meteorologists register ever higher temperatures.

In 2003, Europe was struck by a heat wave that cost 70,000 people their lives, and in 2010, the warmest summer in 90 years killed about 54,000 people in Russia. Since 1998, more than 77,000 Europeans have died as a result of the heat, making heat waves the most hazardous natural disaster on the continent. In 2012, the European Environmental Agency published a report, which concluded that all of Europe is experiencing higher temperatures, and that the heat waves occur more often and last ▶



## Unbearable heat could displace millions

Air humidity is an important measure of how heat affects the body, and to measure the latter, we use the special wet-bulb temperature. A wet-bulb temperature of 35+ degrees is lethal. Scientists from the University of New

South Wales have created a map that shows the world's wet-bulb temperatures, should temperatures increase by 10 degrees. The light colours indicate the regions in which life would be unbearable.

GETTY IMAGES

STEVEN SHERWOOD/UNIVERSITY OF NEW SOUTH WALES



► longer than Europeans have been used to. The report also predicted that the rising temperatures brought about by climate change will make the number of casualties increase in the centuries to come.

### NEW RECORDS EVERY YEAR

In 2015, NASA and the National Oceanic and Atmospheric Administration concluded that the previous year had been the warmest on Earth since the recording of global temperatures began in 1880.

The next year, both organizations made the same conclusion: 2015 had beaten all previous records and was averagely 0.16 degrees warmer than 2014. That is the largest margin ever in connection with a temperature record. The month of December also set a record by being 1.1 degrees warmer than the average of the entire 20th century. That is the largest deviation of one single month ever recorded.

So far, there is no indication that the trend is about to stop. In 2016, scientists proclaimed June to be the warmest month ever recorded, and at the same time, prognoses for 2016 showed that the year would probably also beat the records of the two previous years.



Pilgrims are cooled by water from sprinklers near the Saudi Arabian city of Mecca.

REUTERS/SCANPIX

The ominous records have already influenced the life style of people in the world's warmest regions. In the summer of 2016, when temperatures exceeded 42 degrees in Iraq, public sector workers were allowed to take time off, but they still came to their offices to enjoy the cooling effect of air conditioning.

### THE WORLD CAN STILL BE SAVED

Luckily, most scientists believe that the trend can still be reversed. The message of the 2014 UN climate report, which was prepared by more than 800 experts, was that the average temperature increase on Earth could be kept below two degrees, if world leaders

took action right away, reducing CO<sub>2</sub> emissions drastically.

To curb the fatal heat waves in Europe immediately, scientists from the ETH Zurich have made a wide-ranging proposal. In a study, they discovered that fields that remain uncultivated after the harvest reflect more sunlight than fields that are cultivated. The colour of the unploughed fields is lighter and so, they reflect the sunlight more efficiently, giving off heat.

Some measurements indicated that the unploughed fields could reflect 30 % of the sunlight, whereas cultivated fields only reflected 20 %. Scientists' model simulations showed that the difference means that the reflection of uncultivated fields is consequently 50 % higher. According to the Swiss scientists, that could be enough to reduce the temperatures of local heat waves by up to two degrees.

Global warming is no longer a remote and vague problem. At this point in time, the heat has already fallen on the entire world, threatening to force millions of people to leave their homes, but if the countries on the Persian Gulf listen to scientists and act now, they could still manage to curb the tremendous temperature increases. **SCI**

## Heat keeps planes on the ground

Warm air is thinner than cold air, so the temperature is very important for whether a plane can take off safely.

Heat on the runway can force planes to remain on the ground or turn back and find another airport to land in. An aircraft is designed to function in extreme cold. During an ordinary flight, the temperature outside the cabin can easily fall to minus 40 degrees. A plane is able to take off and land at temperatures of down to minus 67 degrees, but heat quickly causes problems. Warm air is thinner than cold air, providing less lift during take-off and landing. At temperatures of 40+ degrees, pilots could be forced to make the aircraft lighter by leaving cargo or passengers behind. In June 2013, 15 passengers were asked to leave a plane in London City Airport due to high temperatures.

### Cold makes air dense

At sea level and a temperature of 20 degrees, air has a density of 1.204 kg/m<sup>3</sup>.



### Heat makes air thin

At a temperature of 45 degrees, the density is only 1.110 kg/m<sup>3</sup>, corresponding to an altitude of 1,100 m.

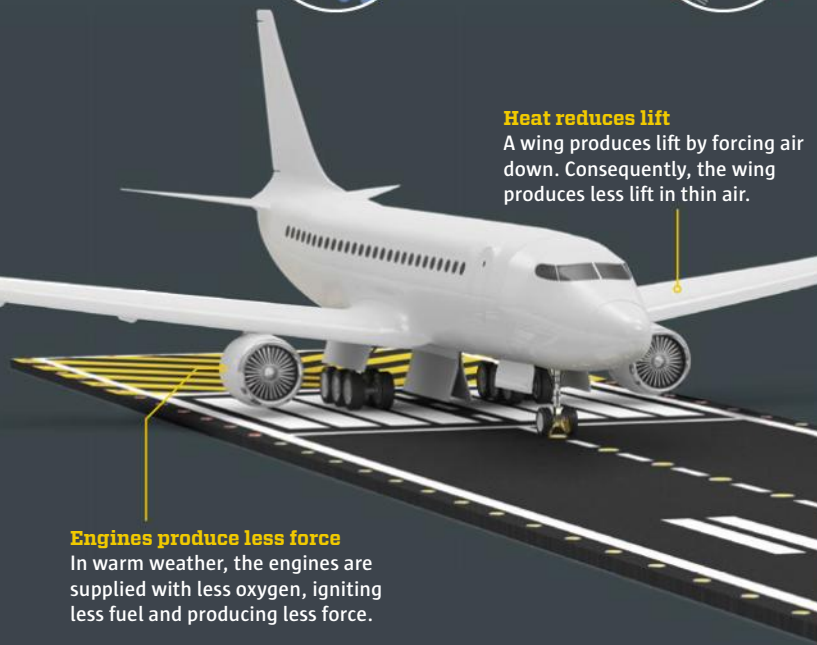


### Heat reduces lift

A wing produces lift by forcing air down. Consequently, the wing produces less lift in thin air.

### Engines produce less force

In warm weather, the engines are supplied with less oxygen, igniting less fuel and producing less force.



SHUTTERSTOCK



# Extreme heat makes mountain range grow

When temperatures become extreme, it could kill die-hard desert bacteria, make the Alps grow higher, and render it completely impossible to fill the petrol tank of your car.

People in the Australian town of Oodnadatta could not fill up their cars until after sunset.

## 1 Petrol evaporated in Australian town

2013 started out extremely hot in the South Australian town of Oodnadatta. During the first week of the year, day temperatures were never below 40 degrees. It was so hot that the Australian Bureau of Meteorology had to

add two new colours to its weather charts to represent the historic high temperatures.

But that was not the only surprising consequence of the heat wave. In the afternoons, filling stations had to give up

selling petrol, because it evaporated, before reaching the tanks of the cars. Motorists were left stranded in filling stations, and had to wait until night or morning to be able to pump petrol into their cars.

## 2 Mountains grow faster

European mountains grow fast. Scientists from the University of Milan have discovered that the heavy glaciers of the Alps have bent Earth's surface. As the glaciers melt, Earth's crust will rise, and the mountains will grow higher. A few decades ago,

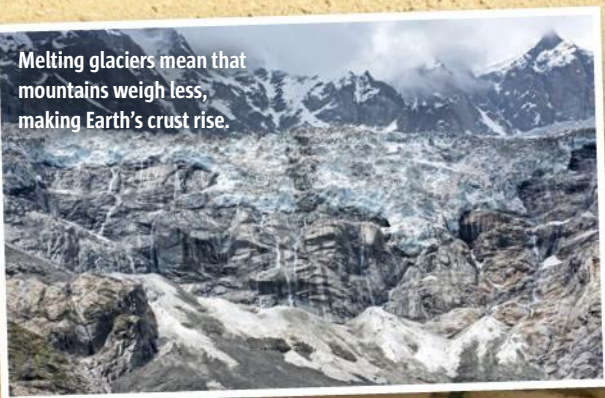
when global warming seriously gathered momentum, the mountains began to grow faster. In France, the mountains grow 0.899 mm per year. Scientists expect that the French Alps will be 4.5 cm higher in 50 years.

## 3 Heat kills desert bacteria

The surface of a desert is teeming with bacteria, which make up a solid crust that prevents sand storms and desertification. Now, scientists have discovered that the *M. vaginatus* cyanobacterium, which is one of two dominant desert

bacterium species, will be wiped out, if temperatures continue to rise. That could have unknown consequences for the world's desert ecosystems. The bacterium binds nitrogen and carbon to the ground, so plants and animals can find nutrition.

Melting glaciers mean that mountains weigh less, making Earth's crust rise.



When desert bacteria die, the ground will be deprived of nutrients.





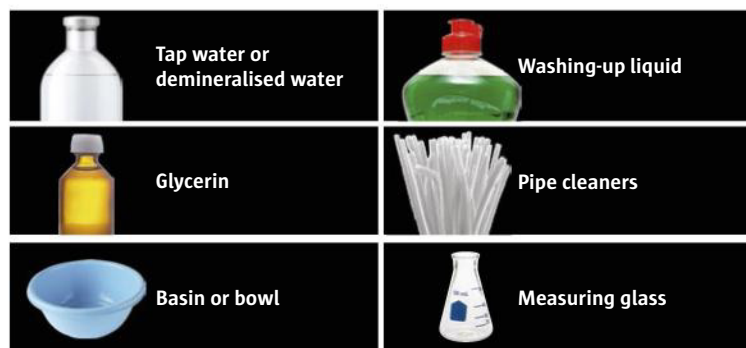


HOME CHEMISTRY LAB

# Durable bubbles

Get your cleaning agents and make your own super bubbles that will last all day.

## YOU WILL NEED:



## GUIDE:

It will take 15 minutes to make the experiment.

1

Place six units of water, one unit of glycerin, and two units of washing-up liquid in a bowl and mix well. Demineralised water will get you the best result, but tap water can also be used.

2

Fold a pipe cleaner into a ring, which can be dipped in the bubble mix.

3

Dip the pipe cleaner in the mix and blow cautiously. You could start all over again and experiment with the mixture of ingredients to see if you can produce an even better result.



Unlike normal bubbles, these contain a lot more washing up liquid which can irritate the eyes, so do not blow the bubbles into the faces of other people.



Use a measuring glass to measure the individual ingredients and mix them in a bowl. Dip a pipe cleaner in the mixture and blow to produce ultra-strong soap bubbles.





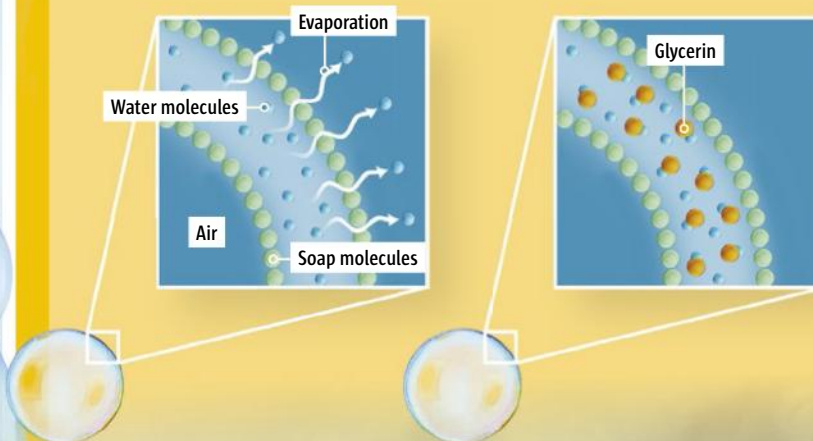
## Soap allows water to bubble

Water molecules stick together too well to produce a bubble. The attraction between them prevents the water from spreading to produce the surface of the bubbles, but soap pushes the molecules apart, stretching the water into a thin film.

A soap bubble's surface is a sandwich of soap and water. Without soap, water cannot produce bubbles, as surface tension holds the molecules together, preventing the water from spreading into a thin film. The surface tension is due to the fact that all water molecules involve electric charges allowing them to attract the surrounding water molecules. Under the water surface, water molecules attract each other from all angles, but the molecules near the surface can only move downwards. The attraction is so powerful that you can pour more water into a

glass than it can actually hold, without any water spilling out. When you add soap to the water, the soap molecules will be located on the surface, squeezing in between the water molecules, so surface tension is reduced. A thin film of water can now be produced, as the soap settles on both sides of the water, keeping down the tension. You make a bubble by blowing at the film. Normally, the bubble will soon become unstable, as the water evaporates, making the film thinner, but if you add glycerin, it will bind to the water, curbing evaporation and making the bubble stronger.

### GLYCERIN STABILIZES THE SURFACE OF THE BUBBLES



#### Ordinary soap bubble

The surface of the bubble consists of a thin film of water encapsulated in soap. The water molecules will soon evaporate, so the bubble becomes unstable and easily bursts.

#### Super strong bubble

Glycerin's electric charges attract the water molecules, and the firm hold prevents water from evaporating. The bubble's surface remains stable and resistant.



# Trivia

> PUT YOUR KNOWLEDGE TO THE TEST

1. Where did the world's (current) oldest living man, 113-year-old Yisrael Krystal, spend most of 1944 and 1945?
2. The South American potoo is closely related to which iconic Australian bird?
3. As of early 2016, which country is now the world's largest single producer of solar power?
4. Online smut giant Pornhub has just launched a socially responsible web portal focusing on what?
5. A molecule getting stuck in a brain protein "for hours" could explain the long-lasting effects of which psychedelic drug?
6. What 14th century plague is estimated to have killed up to one third the population of China?

q. 2

7. The condition called hyperpyrexia, in which body temperature rises to 40 degrees or higher, is likely to cause what?

8. Located in the Milky Way galaxy, what is Sagittarius A\*?

q. 9

9. The ocean sunfish can produce 300 million what at a time, more than any other known vertebrate?

10. With over 160 million items in its catalogue, which is the largest library in the world?

## Trivia Countdown (use fewer clues, get a higher score!)

	5 POINTS	4 POINTS	3 POINTS	2 POINTS	1 POINT
1. HISTORY Name this head of state	He has supported rebel groups in Angola and Ethiopia and cooperated with Chilean president Salvador Allende.	In 1961, he said in a famous speech that "revolution is a struggle to the death between the future and the past".	Richard Nixon described him as a "very dangerous man". Nelson Mandela called him a "source of inspiration".	The Communist leader survived 637 attempted assassinations by the CIA.	He was Cuba's president from 1959 to 2008, when his brother Raúl took over. He died on 25 November 2016.
2. ZOOLOGY Name this creature	During periods of extreme drought, the small creature hibernates, reducing its liquid content from 85 to 1 %.	The animal was first described in 1773 by J.A.E. Goeze of Germany. It probably dates back 540 million years.	The robust creature can tolerate 1,000 times as much radioactive radiation as humans, when it hibernates.	The creature only measures 1.5 mm and exists all over Earth. It can also survive in space, experiments show.	Its official name is Tardigrada, but it owes one of its names to a large, furry animal that loves salmon and honey.
3. ARCHITECTURE Name this structure	in 1076, William the Conqueror began to build this famous fortress, which was expanded over later centuries.	According to local tradition, it is important that ravens be kept in the structure at all times. If not, the nation will fall.	For centuries, the structure was a prison. The last state prisoner was the Nazi Rudolf Hess.	King Henry 8's wives Anne Boleyn and Katarina Howard were both executed behind the walls of the structure.	The British crown jewels are still guarded in the famous castle in central London on the north bank of the Thames.

ANSWERS ON p82!



# USE NEW TECH!

To read about new science and tech!



That's right, you heard right, the Australian Science Illustrated app is out now! Plus, you can check out our other great science title Australian Popular Science.

## WHY GO APP?

- ➔ **Save time!** Receive alerts when the next issue is out!
- ➔ **Save money!** Subscribe for even greater savings!
- ➔ Use your expensive tablet for **something more enriching** than tweets and recipes!

**AVAILABLE NOW ON APPLE NEWSSTAND.**

➔ Load the Newsstand store and search for SCIENCE ILLUSTRATED and POPULAR SCIENCE



**SPECIES:**

Tawny Frogmouth

**SCIENTIFIC NAME:**

*Podargus strigoides*

**DISTRIBUTION:**

Most of Australia except far western QLD, central NT and the Nullarbor

**ICUN CONSERVATION**

**STATUS:** Least Concern (common)



**I AM NOT A LOG EITHER**

During the day, frogmouths adopt a distinctively stretched and thin posture. With eyes closed or opened to the merest slit, they are impressively well-camouflaged against almost any tree. If you have a sizeable garden with large trees, there are almost certainly frogmouths around. You just never see them. You'll probably hear them though, making a deep "oom-oom-oom" in the late evening. Manage to get a torchbeam on one, and the bird will just stare back at you... not moving... daring you to make the next move...

## THE OWL THAT ISN'T

Australia (like New Zealand) is a land of iconic birds. Kookaburra, emu, budgie, sulphur-crested cockatoo, wedge-tailed eagle, galah - you'd never mistake one of those species for any of the others.

One of our birds though is often mistaken for another type. The tawny frogmouth, haunter of midnight letterboxes, maker of weird noises in the dark, possessor of a penetrating yellow-eyed stare, is not an owl.

Not that we blame anyone for making that mistake. Fluffy feathers? Check. Front-facing giant eyes? Check. Hooked, raptor-like beak mostly hidden by tufts and whiskery bits? Check. Nocturnal, spooky, silent-flying and maker of hooty-type noises? All check.

The frogmouth is in fact a type of nightjar. The key difference between them and true owls is that frogmouths

feed on insects. Confusingly, "strigoides", their species name (or "specific epithet" to be scientific about it) means "owl-form" and they will eat baby mice if offered them by, for instance, WIRES rescue volunteers. But a frogmouth is not an owl.

This splendid individual was photographed in a small tree at a highway rest stop near Muswellbrook, NSW. There were five frogmouths all together, sitting quietly in the shade on a very hot December day. It's unusual to see them clustered low to the ground and obvious to the eye like this. Were they caught short at dawn? They wouldn't say...

Since frogmouths live in a wide range of Australian habitats, as a species they need to be able to handle temperatures ranging from as low as eight degrees all the way up to 40+. That's an unusually wide range for a

single bird species, so they have special adaptations for fast panting, and use their wide mouths as radiators.

When it comes to extreme cold, frogmouths can enter a state known as "torpor". It's not quite hibernation - it only lasts for a few hours at a time rather than weeks - but it has the same drop in metabolic function, slowed heart rate, and conservation of energy.

During torpor, a frogmouth's body temperature can drop by up to 10 degrees. For comparison, if YOUR body temperature drops by 10 degrees, you enter severe hypothermia, lose consciousness, and unless rescued by other humans, you will probably die.

Meanwhile, the tawny frogmouth's close South African relative, the potoo, has become a sort of running joke on the internet. Because its eyes bug out, see. That's all it takes. **SCI**

**TRIVIA ANSWERS** 1. In Auschwitz concentration camp 2. Tawny Frogmouth 3. China 4. Sex education 5. LSD 6. The Black Death 7. Death 8. A super-massive black hole 9. Eggs 10. The US Library of Congress Trivia Countdown - Name this head of state: Fidel Castro Name this creature: Tardigrade (aka water bear) Name this structure: Tower of London



# GFX 50S

The Game has changed. **Medium Format** Re-invented.



Fujifilm has always prioritised image quality in its medium format film cameras. Now, after establishing a solid market position in digital imaging, the company is returning to the world of medium format with the launch of the GFX 50S. By using in-depth knowledge of larger format cameras and applying the same philosophy that has run throughout the development of Fujifilm's digital photographic equipment, this camera achieves new standards in photographic quality. The GFX 50S begins a new chapter in camera history.

## FUJIFILM GFX

For more information please visit:  
[www.fujifilm-x.com](http://www.fujifilm-x.com)



Available from leading photographic stores and selected retailers



# MINOX

German.  
Performance.  
Optics.

## MINOX BL HD Line

Comfortable. Lightweight. HD.



8x44 \$1149.00 10x44 \$1199.00



8x33 \$949.00



8x52 \$1349.00 10x52 \$1399.00

Excellent optical  
performance  
.....

High quality, high  
performance HD optics  
.....

Lightweight, compact  
and robust housing  
.....

High resolution,  
neutral colour rendition  
.....

Adjustable  
eyecups  
.....

Wide field  
of view

MINOX BL HD binoculars are characterized by their distinctive lightweight design and open bridge, enabling a comfortable one handed operation. The BL HD series with its innovative anomalous partial dispersion HD glass provides an image free from disturbing colour fringes or glare.

[minox.com](http://minox.com)

 **C.R. Kennedy**  
A COMPANY PTY. LTD.

Ph: (03) 9823 1555 Em: [vjetten@crkennedy.com.au](mailto:vjetten@crkennedy.com.au) Web: [crkennedy.com.au](http://crkennedy.com.au)